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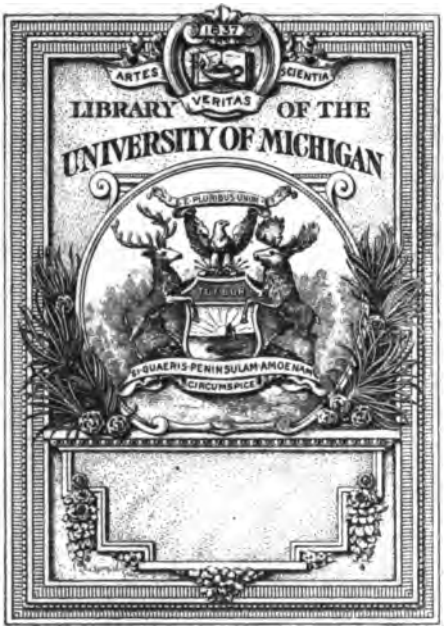

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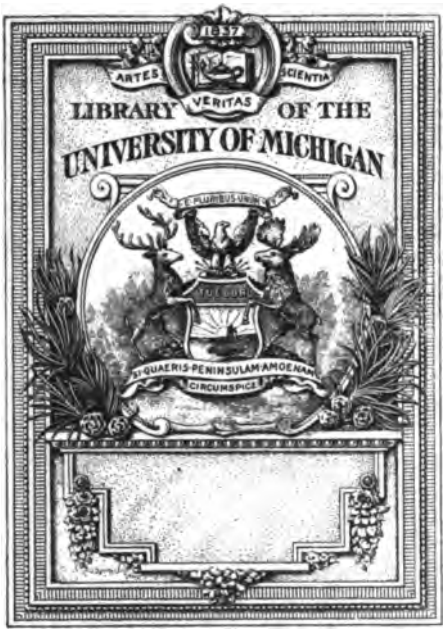

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FOURTH REPORT

OF THE

UNITED STATES

ENTOMOLOGICAL COMMISSION,

BEING A REVISED EDITION OF BULLETIN NO. 3,
AND THE FINAL REPORT

ON THE

COTTON WORM,

TOGETHER WITH A CHAPTER ON THE

BOLL WORM.

BY

CHARLES V. RILEY, Ph. D.

WITH MAPS AND ILLUSTRATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

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CONCURRENT RESOLUTION authorising the printing of thirty thousand copies of the second edition of Bulletin No. 3, or fourth report of the United States Entomological Commission.

IN THE HOUSE OF REPRESENTATIVES,
January 27, 1881.

The following resolution, originating in the House of Representatives, was this day concurred in by the Senate:

Resolved by the House of Representatives of the United States of America, (the Senate concurring,) That there be printed at the Government Printing Office 30,000 copies of the second revised edition, with necessary illustrations, of Bulletin No. 3, of the United States Entomological Commission, being a report on the Cotton and Boll Worms, with means of counteracting their ravages; 10,000 copies thereof for the use of the Senate; 18,180 for the use of the House, and 1,820 for the Interior Department.

Attest:

GEO. M. ADAMS,
Clerk.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 15, 1884.

SIR: On behalf of the United States Entomological Commission, and in accordance with the act of Congress, approved March 3, 1881, which provides that the reports of said Commission be made to the Commissioner of Agriculture, I have the honor to submit this, its fourth report.

Respectfully,

C. V. RILEY,
Chief U. S. E. C.

Hon. GEORGE B. LORING,
Commissioner of Agriculture.

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MEMBERS OF THE COMMISSION.

C. V. RILEY, *Chief.*
A. S. PACKARD, *Secretary.*
CYRUS THOMAS, *Disbursing Agent.*

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PREFACE.

The present volume is the fourth of the reports of the Commission, and was originally designed as a revised edition of Bulletin 3, and a final report on the subject of the Cotton Worm. A single chapter has been added on the Boll Worm, because of the importance of this species, but other insects affecting the cotton plant are only treated of incidentally. A good deal of material has been collected bearing on these other insects affecting the plant, and we hope some day to find time to prepare it for publication. But all work except that on the two principal insects treated of in this report has been considered of minor importance, the main object of the inquiry being as full and accurate knowledge as possible respecting those two, especially in reference to their control or ready destruction by the planter.

The sifting of truth from error; the settlement of mooted questions by test and experiment; the discovery of previously unknown facts and truths, even regarding an insect like the Cotton Worm, require an amount of labor that few will appreciate who have not experienced the difficulties involved; and whatever merit this report may have is due to the fact that the author, in prosecuting the work, has earnestly sought to get at the exact truth, wherever there were conflicting views, experiences, or theories, and because it represents a very considerable amount of original research. He has also endeavored to bear constantly in mind that the chief object which Congress had in ordering the investigation was a practical one, and that whatever purely entomological knowledge was acquired, however interesting to the naturalist, was of less moment, unless it had some bearing on this practical phase of the subject. Hence, descriptive matter and technical discussions are for the most part excluded from the body of the work and printed at the end of the volume in a series of notes for the benefit of the reader who may be interested. Discoveries made in pursuit of some special object often subserve many other purposes and have wide application. This is eminently true in applied entomology, and many of the remedies and the devices for applying them that have resulted from this Cotton Worm investigation are of great use against many other species. This is well illustrated in the modern very general use by farmers and fruit-growers, in all parts of the country, of pyrethrum in the field, of petroleum emulsions, and of the cyclone spraying nozzle, all of which have had their origin in this investigation.

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The character of the investigation was novel. There was no precedent to guide or warn. The number of persons capable, through experience, of intelligent field work in economic entomology was, until quite recently, remarkably small, so that the organization of the force to assist in the work was largely experimental and more difficult than it would have been had trained observers been at command. Under these circumstances, the satisfactory manner in which, with rare exceptions, the different agents have performed the tasks assigned to them is all the more to be commended. Many of these agents have been employed for but a limited time (about three months a year) or to make some special observations or experiments, and the results of their labor are either incorporated in the text of the report or in the appendices. Their work will also be found acknowledged in the introduction, in which we have endeavored to give an epitome of the history of the investigation as well as a glance at the contents of the volume. To all of them, and to the many correspondents who have so willingly and generously assisted, we take this public opportunity of tendering our sincere thanks.

To those who have been more permanently associated with us in this work we desire to express our special acknowledgments and indebtedness. Mr. E. A. Schwarz, from Detroit, Mich., has assisted from the beginning both in field and office work, while since the publication of the first edition Dr. W. S. Barnard, from Cornell University, Ithaca, N. Y., has also been continuously associated with us, and particularly in that phase of the inquiry pertaining to mechanical appliances. Mr. H. G. Hubbard, of Detroit, Mich., Mr. William H. Patton, of Waterbury, Conn., Prof. R. W. Jones, of the State University, Oxford, Miss., Judge L. C. Johnson, of Holly Springs, Miss., Prof. J. E. Willet, of Mercer University, Macon, Ga., Judge J. F. Bailey, of Marion, Ala., Judge W. J. Jones, of Virginia Point, Tex., Prof. E. A. Smith, of the State University, Tuscaloosa, Ala., Dr. E. H. Anderson, of Canton, Miss., Mr. James Roane, of Washington, and Dr. J. C. Neal, of Archer, Fla., all deserve special acknowledgment.

In addition to the observers mentioned, we are indebted to Prof. E. W. Hilgard, of the University of California and special census agent, for permission to use, in the preparation of Professor Smith's chapter and in advance of publication, the notes and observations made by himself and other special agents, while collecting the materials for his Report on Cotton Production in the United States. Mr. E. S. Burgess and Dr. C. S. Minot, of Boston, deserve our thanks for their services in the preparation of Chapter V, and Dr. J. C. Branner and Mr. Albert Koebele for their work in Brazil.

Last, but not least, we would express our indebtedness to those of our office assistants who have in any way contributed to the report: Mr. L. O. Howard for general assistance in the preparation of the report, Mr. Theo. Pergande for care in the breeding of the insects consigned to him, and Mr. B. P. Mann for clerical aid, especially in the preparation of the index.

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The colored plates illustrating the report were either drawn by the writer or by Miss Lillie Sullivan under his immediate direction. Plate IV is reproduced from Glover's copper-plate etchings; Plates VI to XI were drawn by Messrs. Burgess and Minot from material furnished for the purpose; Plates XIV to LXI were either adapted from patent drawings or photographs, or were drawn by Dr. Barnard or by us either from the original machinery or from photographs thereof; Plate LXII is made up from drawings of our own, and Plates LXIII and LXIV were drawn by Dr. George Marx.

C. V. R.

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INTRODUCTION.

The official Cotton Worm investigation, of which this is the final report, was begun in the spring of the year 1878, Congress at that time having appropriated the sum of $5,000 to be expended for the purpose of such an investigation under our direction as entomologist of the United States Department of Agriculture. The results of the first nine months of the investigation are summed up in the following quotations from our report as United States Entomologist for the year 1878. The quotation also includes the first circular issued in the progress of the investigation:

INSECTS AFFECTING THE COTTON PLANT.

Pursuant to an appropriation by the last Congress for the purpose, and in accordance with your instructions, I have carried on a special investigation of the insects injurious to the cotton plant. The commission of inquiry was organized by the appointment of the following gentlemen: As special agents, Prof. J. H. Comstock, of Ithaca, N. Y., whose position as professor of entomology in Cornell University and whose experience with insects injurious to vegetation had well fitted him for such labor; and Prof. A. R. Grote, of Buffalo, N. Y., whom a residence of several years at Demopolis, Ala., and a special study of the Cotton Worm, had also well prepared for the inquiry. As local agents and observers: Dr. E. H. Anderson, of Kirkwood, Miss.; William J. Jones, of Virginia Point, Tex.; Prof. J. E. Willet, of Macon, Ga.; and Prof. Eugene A. Smith, of Tuscaloosa, Ala. Mr. E. A. Schwarz, of Detroit, Mich., has also been engaged during the winter to visit all the Southern States and the West India islands, with a special view of getting at the facts of hibernation. To Professor Comstock was assigned the cotton region of Arkansas and Tennessee and of Mississippi and Alabama north of Vicksburg and Meridian and the Alabama Central Railroad; to Mr. Grote that of Florida and Georgia and of Alabama south of the railroad mentioned; while, with the assistance of the local observers, I have myself given more especial attention to the extremities of the belt, viz: Texas, Louisiana, Southern Mississippi, and the Carolinas.

The following circular-letter was prepared for the use of agents, and distributed, with corresponding blanks, to correspondents in the cotton belt. It will explain the scope of the inquiry:

DEPARTMENT OF AGRICULTURE,
Washington, D. C., July 22, 1878.

SIR: The entomologist of the department having prepared a series of inquiries for the special scientific observers to whom has been assigned the duty of studying the history and depredation of the worm known as *Aletia argillacea*, as well as other insects which injure the cotton plant, I have caused copies of these circulars to be printed and sent you, in hope that you may feel interest enough in the subject to make report thereon.

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Should you do so, please observe carefully the following suggestions:

Write only on one side of the paper blanks sent; and, if more room is desired to answer fully, write on another sheet, numbering and lettering to correspond with letter and number of question.

If any special points arise before the termination of the season, please communicate freely, marking your envelope "cotton insects."

Respectfully, &c.,

WM. G. LE DUC, *Commissioner.*

THE COTTON WORM.

This insect (*Aletia argillacea*,* Hübn.) will naturally receive most attention, being, as it is, by far the most injurious of the different enemies of the cotton plant. Data are requested on all the following topics:

PAST HISTORY OF THE COTTON WORM.

1. Give, so far as you can from trustworthy records, the earliest year in which cotton was grown in your State, county, or locality.

1*a*. During what year (exact or approximate) did the worm first make its appearance in your locality, and, as far as you are aware, in the State; in other words, how many years elapsed after cotton first began to be grown before the worm began to work upon it?

1*b*. Specify the years when it has been unusually abundant and destructive.

INFLUENCE OF THE WEATHER ON THE INSECT.

2. State what you know from experience of the effects of weather on the insect, and more particularly—

2*a*. The character of seasons most favorable to its increase.

2*b*. The character of the summer and winter—whether wet or dry, mild or severe—that have preceded years in which the worm has been abundant and destructive.

2*c*. Do wet summers favor its multiplication?

2*d*. Effects of different kinds of weather on the eggs.

2*e*. Effects of different kinds of weather on the moths.

2*f*. Month of year when greatest injury is done.

STATISTICS OF LOSSES.

3. Give, as correctly as you can, estimates of the loss to the crop in your county and State during notable cotton-worm years.

MIGRATION OF THE MOTHS.

It is a well-established fact that the parent moth of the Cotton Worm is often found in autumn many hundred miles away from the cotton belt, and there is no reason to doubt that it is often carried by favorable winds to northward regions, where it cannot perpetuate its species and must therefore perish. Mr. A. R. Grote and others even believe that the species perishes each year with the plant, and that the moth always comes into the cotton States from more southern countries, where the cotton plant is perennial; in other words, that the moth is habitually migratory, and cannot survive the winter in the great cotton regions of the States. While there are many facts that lend weight to this theory, there is also much to be said against it; and we desire to collect all facts that in any way bear on the question. While we hope to get much valuable information on this head from the Signal Bureau, we also ask for the experience of correspondents.

4. Please state, therefore, as nearly as you can from the records, the *prevailing* direction and force of the wind in your locality, first,

4*a*. In the month of February; second,

4*b*. In the month of March; third,

4*c*. In the month of April; fourth,

4*d*. In the month of May; fifth,

4*e*. In the month of June; sixth,

4*f*. Whether, in your opinion, there are winds from the south that are sufficiently strong and constant to counteract the prevailing trade-winds, which are toward the equator.

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* The *Noctua xylina* of Say.

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4*g*. The prevailing direction of the wind from July till frost.
4*h*. The side of a field on which the worms first begin to work.
4*i*. Do local topographical features influence the extent of the worm's ravages?
4*j*. Does or can the worm feed upon any other plant than cotton, and have you ever known it to do so?

HABITS AND NATURAL HISTORY.

These have already been studied, and are pretty well known; but experience will differ somewhat with locality, and we call attention to the following topics:
5. State the time when the first moths are noticed in your locality.
5*a*. Date when the first worms have been noticed in past years.
5*b*. Date when the last worms have been seen in past years, or were noticed the present year.
5*c*. Number of broods or generations of the worms generally produced.
5*d*. In what other situations besides the folded cotton leaves have you known the worms to spin?
5*e*. Have you ever known the chrysalis to survive a frost, or to be found in sound and healthy condition in winter?
5*f*. Have you ever found the moth hibernating or flying during mild winter weather?
5*g*. How late in the spring has the moth been found alive?

NATURAL ENEMIES.

It is a little singular that no enemies of the Cotton Worm have hitherto been reported. That the insect has its enemies, both special and general, there can be little doubt, and we would ask particular attention to the following topics:
6. Are any birds, quadrupeds, or reptiles known to attack the insect in your locality?
6*a*. Are any predaceous insects or parasites known to prey upon it, either in the egg, larva, or chrysalis state?

REMEDIES AND METHODS OF DESTRUCTION.

7. What has been the result of the efforts to allure and destroy the moths, and what methods have proved most satisfactory? Give your estimate of the relative value for this purpose of poisoned sugar, molasses and vinegar, and fires.
7*a*. Are the moths most attracted to sweetened substances when smeared onto trees, boards, &c., or when contained in vessels in or near which lamps may be lighted?
7*b*. Are any flowers known to be attractive to the moth? If so, specify them and their season of blooming.
7*c*. What do you know of your own observation of the influence of jute grown near or with the cotton?
7*d*. Has any effort been made to destroy the moth in its winter quarters?
7*e*. Have any systematic and organized attempts been made to gather and destroy the chrysalides, or to facilitate their collection and destruction by furnishing inviting material for the worms to spin up in?
7*f*. What has been done toward destroying the eggs?
7*g*. Has anything been found more generally useful and applicable or cheaper than the use of the Paris green mixture to destroy the worms?
7*h*. Have you known of any injurious effects following the use of this poison, either to the plant, to man, or to animals?
7*i*. State what you consider the best and most effective method of destroying them in your section.
7*j*. State the cost per acre of protecting a crop by the best means employed.
We shall be glad to receive figures, either photographs or drawings, of machines or contrivances employed for the wholesale use of the Paris green mixture, either in the fluid state or as a powder; or any other kinds of machines or traps employed for the destruction of the insect. Models of such are still more desirable, and may be sent by express unpaid to the department.

OTHER COTTON INSECTS.

There are many other insects that attack and do more or less injury to the cotton plant. Many of these have been figured and referred to by the former entomologist to the department, Mr. Townend Glover, but there is much yet to learn of their habits and natural history and of the best means of subduing them. Specimens of all insects that may be found upon the plant are, therefore, earnestly solicited, with accounts of their work and habits and the amount of injury they do. These specimens are best sent by mail, in tight tin or wooden boxes. If living (and all found

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feeding on the plant should thus be sent) a supply of food should be inclosed with them; if first killed, they should be carefully packed in a little cotton, to prevent shaking and breaking.

Correspondents who desire to make especial observations with a view of replying to this circular, and who wish further information as to the best manner of preserving specimens, will receive assistance and further instructions upon communicating with the department.

CHAS. V. RILEY,
Entomologist.

Two circumstances have somewhat interfered with the inquiry, viz, the yellow fever and the general freedom of the plant from the Cotton Worm, the serious injuries of this last having been restricted to the cane-brake regions of Alabama and to the southwest counties of Georgia, especially the country between the forks of the Flint and Chattahoochee Rivers—the more malarious portions of either State. Its appearance in injurious numbers, both here and in South Texas, was from four to six weeks later than usual, and this was one cause of the small amount of injury done. The weather at the time of their greatest abundance was wet and interfered with the application of remedies.

Professor Comstock's observations were chiefly confined to that fertile cotton-growing region along the line of the Alabama Central Railroad, known as the "cane-brake." He reached Selma July 20. There he met many prominent planters, and from them collected important statistics respecting the occurrence of the Cotton Worm and the results of experiments in the use of remedies for this species. July 23 he began his field observations near Uniontown, Perry County, and from that time on, till the middle of October, he was constantly engaged in studying the habits of cotton insects on plantations in Dallas, Perry, Hale, and Marengo Counties. His only absence from this region was from August 10 to August 15, when I directed him to make a trip through the State northward as far as Madison County, where much cotton is grown. Professor Comstock has prepared a full and valuable report, which will be incorporated in the final report of the investigation.

Professor Grote's operations will appear by the following extract from a brief report submitted.

"SIR: In accordance with your favor of July 18, in which you directed me to visit the States of Georgia and Florida for the purpose of making observations on the insects injurious to the cotton plant, I proceeded to Savannah and during the following month of August made examinations of cotton fields at different points between Savannah and Atlanta. Having charged me especially with that phase of the cotton-worm inquiry which comes under the head of migrations, I directed my chief attention to making observations and collecting information on the appearance and movements of the Cotton Worm (*Aletia argillacea*).

"A careful survey of the plantation of Dr. Lawton, near Savannah, from August 1 to August 7, and the cotton patches in the vicinity convinced me that the worm had not then appeared. The statements made to me were to the effect that its earliest appearance was usually to be looked for about the middle of the month. Henry Gaston, engaged in planting cotton for nearly twenty years, said that the first brood of worms web up about the middle to the latter part of August, giving a second brood in September. The worm was first noticed in the stronger cotton on the bottom lands. * * * He had observed the moth before the appearance of the worm, but had never noticed it in the early spring.

"This testimony is given as a sample of the information collected from various individuals. While August seems to be the usual time for the appearance of the worm on the mainland on the coast of Georgia, in the neighborhood of Savannah, the testimony of Dr. J. S. Lawton, on the sea islands off the coast of South Carolina to the northward of Savannah, is to the effect that the worm appears sometimes as early as July and is then usually excessively injurious to the long-staple cottons.

"In Southwestern Georgia the worm is noticed as early as the last week in June in some years, and the main damage inflicted in the State seems to come from this quarter. The worm occurs there every year, though the date at which it is noticed varies. The question whether the so-called 'brood' is the first appearance of the worm in any quarter has been raised by yourself, and is one which I hope to be able to pay close attention in the spring.

"For the present we must accept the testimony that the worm seems to advance from Southwest Georgia over the western and occasionally over the central portion

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of the State. It seems to come from Decatur to Baker, Calhoun, Dougherty, and Lee Counties. According to present testimony its appearance is not simultaneous over this section of the State, the southern portions being first visited.

"From testimony collected by myself in Athens, on the occasion of the meeting of the Agricultural Society of Georgia, the following counties are visited by the Cotton Worm every year, though the exact line is not, according to testimony, the same: Calhoun, Decatur, Dougherty, Lee, Mason, Schley, Taylor.

"Counties in which the worm is not noticed every year are: Burke, Clarke, Fulton, Greene, Hancock, Jones, Monroe, Putnam, Richmond.

"It will be seen that the central portion of the State is less subject to the devastation of the Cotton Worm than the southwestern and western. * * *

"I received in November, 1878, fresh instructions from you to proceed to Georgia for the purpose of ascertaining whether I could find eggs from the last moths on any portion of the plant, and any facts bearing on the hibernation of the moth. On the plantations near Savannah I found that the worm was first noticed the current year on September 4. I found a large number of the chrysalides yet on the plant on November 10 to 25. The nights were frosty and the leaf withered and scant. In places sheltered by trees the leaf was still green, and here I found (November 16) a few caterpillars not yet spun up. A large number of the chrysalides were empty; about 40 per cent. contained parasites. Less than a quarter of the chrysalides contained the undeveloped moth.

"Under your instructions I have visited the Georgia sea-islands during the end of November and beginning of December. I found that the worm had appeared this year in September as on the mainland, but later in the month. It had, also, not spread, and had attacked certain corners of the fields, where I now found the chrysalides. None of these contained undeveloped moths, but they were either empty or ichneumonized. There had been no second brood of worms on the islands, according to testimony collected by me, and which was borne out by my own observations.

"As the result of my late observations I may say that the fact is confirmed that the Cotton Worm passes the winter, when it survives at all, as a moth, and that the last fall worms do not leave the plant to web up. The full history of the worm in Georgia can be made out when the country is fully explored in the spring and before the first appearance of the worm in numbers. It will then be made clear where the first large numbers of the worm come from; whether they are the results of fresh invasions of the moth or the product of a first generation from eggs of hibernating individuals.

"Under your intelligent supervision of the inquiry, and with the facilities which you possess from different sections of the South, I have no doubt that this important matter will receive final and full elucidation.

"My thanks are due to Mr. Z. Bauers, of Saint Catharine's Island; Dr. W. S. Lawton, of Savannah; Messrs. T. G. Holt, of Macon, Ga.; J. E. Redwine, Hull County, Georgia; E. C. Grier, Griswoldville, Jones County; J. Pinckney Thomas, Wayne's Bluff, Burke County, Georgia; State Geologist George A. Little, of Atlanta, Ga., and others, who have assisted me in my work.

"Yours, respectfully,

"A. R. GROTE.

"Prof. C. V. RILEY,
"*Entomologist, Department Agriculture.*"

Starting south myself the latter part of August, I passed through Tennessee to Mitchell County, in Southwest Georgia, and thence, during September, through the cotton sections of the southeastern part of that State and of the Carolinas and Virginia. I was at this time made painfully aware of the hindering effects of the yellow fever. One can scarcely conceive of the panic and excitement that prevailed, even in regions where there was little or no danger. But a few weeks before in the thicker cotton counties of Alabama and Georgia the prevailing topic of conversation, as I learned, was the work of the Cotton Worm. At the time of my visit its injuries were forgotten in the all-absorbing subject of the epidemic. Cotton fields were neglected, and in sight of acres of stripped and spindling stalks one heard but the universal refrain—yellow fever, yellow fever. It seriously interfered with my own plans, and obliged me to avoid the very Mississippi cotton fields which I desired most to visit.

Notwithstanding this serious drawback to the present year's operations, much that is valuable and important has been learned. * * *

In fact, our chief efforts during this first year as United States Entomologist were devoted to this investigation, and a large amount of mate-

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rial had been accumulated for a special report on the subject, of which Congress ordered (March 3, 1879) 10,000 copies to be published. In the spring of 1879 the investigation was, by act of Congress, transferred from this department to the United States Entomological Commission, which was then under the Interior Department. Owing to difficulties which grew out of this action, we resigned the position of entomologist to the Department of Agriculture, under Commissioner Le Duc, to take effect May 1, 1879, and at the next formal meeting of the Commission, in subdividing the labors of its members, this cotton-insect work was assigned to the writer. He has, therefore, had entire charge of the same, and is alone responsible for the work and for this report.

The historic facts just related have no interest here except as they necessarily bear on the investigation, which Congress evidently intended to be continued under the same direction as that under which it had been instituted. But, as we have just seen, a special report on the subject under the Department of Agriculture had been ordered. Under these circumstances it became very desirable not only that the work we had done on that report should be properly brought to a close, but that there should be no duplication of work subsequently and no conflict between the Department and the Commission. We left the Department with the hope that such would be the case, and in the appointment of Prof. J. H. Comstock as our successor we anticipated the realization of our hopes, not only because of his assurances to that effect and to the effect that those who had been associated with us in the office and were familiar with the work and our plans should be retained, but because he himself had done the most efficient field work as one of our assistants and was well qualified to complete the report. However much we may regret that those hopes were subsequently not realized, or deplore the subsequent action of the Department in actively continuing this special investigation and in opposing the Commission, it is sufficient, in this connection, merely to mention the facts.

Preparations were made, in accordance with the law, to continue the work under the Commission after July 1, 1879. The following circular was sent to correspondents:

[Circular No. 7.]

RELATING TO THE COTTON WORM.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE U. S. ENTOMOLOGICAL COMMISSION,
———— ————, 18—.

Mr. ————:

DEAR SIR: The undersigned has for many years keenly felt that there was great need of more accurate knowledge of the habits of the Cotton Worm (*Aletia argillacea*) and of the other insects injuriously affecting the cotton plant, as also of more satisfactory means of counteracting their injuries. Recognizing the vast importance of the subject to the people of the South, one of his first efforts, after accepting the position

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of entomologist to the Department of Agriculture, in May, 1878, was to commence a special investigation looking to those ends.

An appropriation to the Department was obtained for the purpose, and the investigation was carried on under his direction up to the time of his resignation, on the first of May last. Since that time Congress has required the United States Entomological Commission to continue the work, and said Commission, at a late meeting, decided to place this part of its work in his charge. On behalf of the Commission, he would, therefore, call the attention of correspondents to the following questions and topics, with the request that answers thereto, or experience thereon, be returned to him some time before October next.

Some correspondents whom this circular will reach may already have answered a more detailed one, sent out last year by the writer while connected with the Department of Agriculture. He would beg such to again give their experience on the fewer topics of the present circular.

He will be glad to receive figures, either photographs or drawings, of machines or contrivances employed for the wholesale use of the Paris-green mixture, either in the fluid state or as a powder; or any other kinds of machines or traps employed for the destruction of the insect. Models of such are still more desirable, and may be sent by express, unpaid, to the headquarters of the Commission. Correspondence is solicited whenever any expense must attend the carrying out of these requests, in order that authority may be given to make the necessary outlay and thus insure the refunding of the amount.

Respectfully,

CHAS. V. RILEY,
Chief U. S. E. C.

1. During what year was cotton first grown in your State, county, or locality?
2. How many years elapsed after cotton first began to be grown before the worm began to work upon it?
3. Is the worm most dreaded after a mild or after a severe winter?
4. Do wet or dry summers favor its multiplication?
5. What is the earliest date at which you have known the worm to appear in spring?
6. In what locations does it most often first appear?
7. What is your experience, and what are your views, as to the winter habits of the insect?
8. What natural enemies of the worm among birds, quadrupeds, or insects are you familiar with?
9. What has been the result of the efforts to allure and destroy the moths, and what methods have proved most satisfactory? Give your estimate of the relative value for this purpose of poisoned sugar, molasses, and vinegar, or other poisonous substances, and fires.
10. Are the moths most attracted to sweetened substances when smeared upon trees, boards, &c., or when contained in vessels in or near which lamps may be lighted?
11. Are any flowers known to be attractive to the moth? If so, specify them and their season of blooming.
12. What do you know, from your own observation, of the influence of jute grown near or with the cotton?
13. Has anything been found more generally useful and applicable, or cheaper, than the use of the Paris-green mixture, or of arsenic in some form, to destroy the worms?
14. Have you known of any injurious effects following the use of this poison, either to the plant, to man, or to animals?
15. State what you consider the best and most effective method of destroying the worms in your section.
16. State the cost per acre of protecting a crop by the best means employed.

Correspondents will confer a favor by numbering the replies to correspond with the questions, and by writing on but one side of the paper.

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The appropriation was limited that year, and on that account a limited force of assistants was employed. Mr. Schwarz spent considerable time in the Colorado bottom, at Columbus, Tex., and later at Selma, Ala., with Mr. Patton. We spent some time at both places with these gentlemen, and visited a number of other points at which there seemed opportunity of gaining experience or information. But our time was much taken up with the office work of the Commission and with the preparation of Bulletin 3, or the first edition of this work. This was issued January 28, 1880, or within seven months from the time the Commission took charge of the work. A summary of the work of the year is given in the introduction to that Bulletin, from which we quote the following passage, by way of deserved credit to some of the earlier students of the Cotton Worm, and particularly to the first entomologist of this department, since deceased:

> The need of such an investigation, and even of a much more thorough one than the limited means so far appropriated therefor by Congress have permitted, is, I venture to believe, made apparent from the following pages. Mr. Townend Glover, during his earlier connection, as entomologist, with the Patent Office and the Department of Agriculture, gave much time to the study of the insects affecting cotton, and published in the Agricultural Reports for 1854 and 1855 much valuable information there anent, which has been a text for most subsequent writings on the subject. The science of entomology was then in its infancy in this country, and Mr. Glover labored under many difficulties in the proper determination of species and in other ways, which necessarily prevented that scientific accuracy and thoroughness which is desirable. Yet to his labors and those of a few Southern men like the late Thomas Affleck, of Brenham, Tex., and Dr. D. L. Phares, of Woodville, Miss., we owe all that was known and in any way reliable on the subject up to within the present decade; while his copper-plate figures of the principal insects affecting the plant, of which figures he published in 1878 a limited number of copies for distribution at his own expense, are so admirable and instructive that it is cause for regret that they were not long since issued, with appropriate text, by the Department of which he was so long the entomologist.
>
> It may safely be said that up to 1878 scarcely any facts had been added, by direct observation, to those which Professor Glover had published regarding the Cotton Worm twenty-five years ago.

Just before the issuing of Bulletin 3 a circular was sent through the State Department to consuls and consular agents in different localities in Mexico, Central and South America, asking for such particulars concerning the enemies of the cotton plant as might bear upon the question of annual immigration. The answers to this circular were received too late for insertion in Bulletin 3, but they have been used in the preparation of Chapter IV, and will be found in full, together with the text of the circular letter, in Appendix VII, page [59] of this volume.

During the year 1880, by virtue of increased means provided by Congress, the investigation was carried on with more vigor. Among temporary employés engaged for special work, Judge W. J. Jones acted as agent in Southern Texas, Prof. R. W. Jones was engaged in Mississippi making extracts and decoctions of different native plants to be tested as insecticides, and also in making special observations on the

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Boll Worm, while Dr. Anderson and Judge Johnson represented the Commission in their respective parts of the same State, making experiments themselves and also assisting Professor Jones. Mr. Roane was located for some time at Selma, Ala., making extracts and decoctions of various native plants in that region, while Judge Bailey represented the Commission in the cane-brake region of the same State, and was more particularly charged with what pertains to the food habits and hibernation of the parent moth. In Georgia Professor Willet made a series of experiments to test the value of fungus germs in the destruction of the worm. Professor Smith, of Tuscaloosa, Ala., was engaged in the work on the cotton belt, represented in Chapter VI. Prof. J. P. Stelle, of Mobile, Ala., spent nearly five months in Texas, traveling from place to place, under special instructions as to observations, while Mr. Patton, in addition to assisting in the office work, spent part of the summer at Selma, Ala. Here, also, Mr. Schwarz was stationed, as we found it convenient to make this point a sort of field headquarters for the work, especially the testing of remedies and remedial appliances. Mr. Hubbard was stationed in Florida, principally at Centreville and Crescent City. Dr. Barnard had his headquarters at Vidalia, La., in the early part of the season, making notes in portions of Louisiana and Mississippi, but later in the season joined the force at Selma, where he gave more particular attention to the machinery experimented with. Whatever time could well be spared from the office work of the Commission we devoted to field work, visiting during the months of July, August, September, and October the different agents, and personally aiding and suggesting in the carrying out of plans and instructions.

These instructions were given in special correspondence with the agents, as also in Circular No. 7, and in the following supplementary circular letter:

SUPPLEMENTARY INSTRUCTIONS TO AGENTS.

OFFICE OF THE U. S. ENTOMOLOGICAL COMMISSION,
No. 1700 13*th Street, Washington, D. C., July* 30, 1880.

In addition to instructions already transmitted to you, I hereby call your attention to a few important points which should have especial attention.

In the application of poisons already known to be effectual the great desideratum is to ascertain the minimum quantity that can be used successfully. It is my intention to perfect appliances that will throw either an extremely fine mist or an almost impalpable cloud of dust from near the ground up among the plants and on the under side of the leaves.

Test, therefore, thoroughly, by a series of experiments, whether:

1. London purple, Paris green, or arsenic can be used without diluents by forcing them dry in minimum quantity, onto the plants, and ascertaining how much ground a pound of each may be made to cover.

2. If they cannot be used without diluents, the minimum quantity of such diluents necessary.

3. How far, by fine spraying, and economy in preventing wastage on the ground, the number of gallons of water to a pound of these materials may be reduced—the

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idea being, in all these desired experiments, to reduce the bulk and expense of the diluents by forcing the poisons in finer and fewer particles up among the plants rather than down upon them, through small perforations, or (what will prove preferable) crescent-shaped slits of various dimensions in nozzles that will bear great pressure from within.

4. Test how far, *i. e.*, over how much ground, on the above principles, a pound of pyrethrum may be made to go and still prove effectual.

5. Ascertain, if possible, whether the moths are not killed by sucking at the glands where the plant is poisoned from below.

6. Ascertain the effects of these different poisons on the eggs.

7. Always note the difference in effect on the very young and the full-grown worms.

8. Observe well in the woods and in the neighborhood of infested fields if the Aletia larva can be found feeding on any other plant, searching particularly plants of the same family (*Malvaceæ*) or that to which cotton belongs.

9. Note and study any mites found preying on the eggs.

10. Send me a summary of the experiments made with yeast ferment or beer mash by the middle of August.

11. Study well the influence of ants in the cotton field and in how far they prove destructive to Aletia, especially to the egg or young larva.

Respectfully,

C. V. RILEY,
Chief U. S. E. C.

Another circular (No. 10) referred to other insects affecting either the root, stem, branch, leaf, involucre, blossom or boll, but, for reasons stated in the Preface, need not be repeated here.

In the meantime the work we had left unfinished in the Department, together with some additional work done by Mr. William Trelease under direction of our successor, had been prepared for publication, and was issued in August, 1880, by Professor Comstock as author, under the title: Report | upon | Cotton Insects | prepared | under direction of the Commissioner of Agriculture in pursuance of an Act of Congress approved June 19, 1878 | By | J. Henry Comstock | Entomologist to the Department of Agriculture | Washington | Government Printing Office | 1879 | . This is referred to in the following pages either as the "Department Report on Cotton Insects" or as "Comstock's Cotton Insect Report."

On July 1, 1881, the U. S. Entomological Commission was transferred by previous act of Congress from the Department of the Interior to the Department of Agriculture, and we were soon thereafter asked to resume the position, which we had resigned two years previously, of entomologist to this last Department, under whose auspices the investigation has since been carried on. The work in 1881 and 1882 was chiefly devoted to the preparation of the present report and to the testing and perfecting of the machinery that had been devised, the Cotton Convention held in the autumn of 1881 at Atlanta, Ga., offering a favorable opportunity, and much time having been given to the preparation of an exhibit of such machinery, which the Commissioner desired should be made there. Such further experiments as were made with insecti-

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cides were incidental to those made previously, and have been recorded in the publications of the Entomological Division.

The preparation of this report for the printer was virtually finished by the end of 1882, and we owe it to ourself and to the public to explain here the reasons for the delay in its appearance. The chief reason has been the desire on our part to have all the more practical questions as satisfactorily settled as possible, and every one who has been engaged in such work knows how one experiment suggests and begets another, and how difficult it is to close up experimental work that one is deeply interested in. We also felt the need of more exact knowledge of the facts in reference to Aletia in Brazil as bearing on the hibernation and introduction of the species within the States. In pursuit of information upon these points and upon questions concerning the cultivation of cotton in Brazil, Dr. John C. Branner, a gentleman familiar with Brazil through his connection with several exploring expeditions, was sent to that country with an assistant, Mr. A. Koebele, in the winter of 1882–'83. They remained there some four months and collected a large amount of interesting material, returning in May, 1883. Dr. Branner's preliminary report was published in Bulletin 4 of the Entomological Division, pp. 51–69, and that portion of his final report which treats of cotton insects forms Appendix V of the present volume. The remainder of his report is published in Miscellaneous Special Report No. 8 of the Department, under the title "Cotton in the Empire of Brazil; the Antiquity, Methods, and Extent of its Cultivation; together with Statistics of Exportation and Home Consumption."

Then during this time the third report of the Commission was being prepared and issued, while the labors of the divisional work since 1881 have been greater than ever before. We have, both from choice and from necessity, made the finishing of the literary work of the Commission, which expired June 30, 1882, secondary to our duties as entomologist to the Department, and the general work of the Division, together with the preparation of the bulletins and annual reports issued since 1881, have helped to increase the delay. Finally, there are delays incident to Government publication which those who have had experience with it very well understand, but which the outside public cannot well appreciate. The chief of these is that the Government Printer finds it necessary to set aside work on special reports during the sessions of Congress, so that the summer months are the best to get work done on such special reports—the time of year, unfortunately, when, from the very nature of the work of the entomological Division, the entomologist is most occupied with the prosecution of research and has least time for literary or editorial work. Yet the fact remains that the report proper was formally submitted in March, 1884, and the bulk of it was in type, with all the illustrations made, by the fall of that year. If the foregoing account of the investigation upon which this report is based and explanation of the delay in its appearance indicate some of the difficulties

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that have beset its preparation, it must be remembered that they are such as are incidental to most scientific work of an official nature, or done under the Government. We hope and believe, notwithstanding, that the work will prove of standard value to all in any way interested in the matter of which it treats.

Chapters I and II, pertaining to classification, nomenclature, destructiveness, characters, habits, and natural history of the Cotton Worm, are condensed as much as possible. The reasons for abiding by the specific name of the species originally proposed by Say are more fully given in Note 2 than in the text, and if the statements in regard to habits and natural history have at times the appearance of being dogmatic where they conflict with previous statement by others, it is because the facts have been so fully studied as to leave no room for question. The full hibernation of the species, within our limits, was not established till the spring of 1882, by our finding the newly-hatched worms the latter part of March on rattoon cotton in South Georgia and Florida, but it was to Mr. Koebele's unflagging industry (chiefly at night), while stationed at Archer, Fla., for this purpose, that the hibernating moths were obtained during the months of December, January, February, and March.

Chapter III consists of a summary, with as little detail as possible, of the past marked appearances of the Cotton Worm in the United States chronologically given, and of the history of remedies proposed for it. The history of the literature is given separately in Chapter XIV.

In Chapter IV brief consideration is given to the distribution of *Aletia xylina* in other countries than the United States, showing that it is confined to the Western Hemisphere.

Chapter V, by Messrs. Minot and Burgess, treats of the anatomy of Aletia by two competent histologists, and while it will have interest principally for the scientific reader, it will prove a valuable contribution to a phase of the subject hitherto untouched.

Chapter VI, by Professor Smith, treats of the cotton belt, its general characteristics, and its peculiarities from meteorological, agricultural, arboricultural, and geological standpoints. This subject of the cotton belt and its characteristics is one that always interested us from the possibility that, after careful study, it might indicate the preferred hibernating regions of the moth. Its proper consideration required not only a thorough knowledge of the country, but geological knowledge which we did not possess, and it is doubtful whether one could be found more thoroughly fitted to consider it than Professor Smith. His work has shown, if anything, that there is not, as we anticipated there might be, any necessary connection between the surface characteristics of the country and hibernation. This last evidently depends more on mean winter temperature and earliness of spring, and if any conclusion is warranted, it would seem to be that the dark, low, and rich soils most conducive to the increase of the worm are not the most conducive to

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the winter preservation of the moth, which finds its most favorable winter conditions in the sheltered pine regions and dry sandy soil covered with wire grass. But aside from this Professor Smith's chapter will have a deep interest for cotton planters.

In Chapter VII we have briefly considered the influences, direct and indirect, which the character and condition of the soil, of the plant, and of the weather have upon the first appearance of the worms and upon their increase and destructiveness—a subject, as the context shows, of no mean importance.

In Chapter VIII the natural enemies of the insect are treated of and their value as checks to its increase considered. The list is a long one, and those of its own class are treated of systematically. Many previous errors are here corrected and a number of pertinent entomological facts for the first time published. When the investigation began not a single true parasite had been recorded by name, whereas over a dozen are here recorded.

In Chapter IX we have dealt with such preventive measures as are worthy of consideration by planters, while in Chapter X we have dealt at length with remedies, *i. e.*, with means of coping with the insect, whether in the egg, larva, pupa, or imago state, but more particularly with substances that may be used for the destruction of the worm. This is the chapter which will probably prove of greatest value to those for whom the report is primarily intended, and we bespeak its careful consideration. While many substances are considered which have no value whatever, yet negative results once established have a decided value in preventing future waste of time and energy in futile work, and the matter of the chapter is based on original research and experiment. In treating of the use of yeast ferment or other fungus germs we have used essentially the language of the first edition. Time has only served to confirm us in our opinion of their practical futility in the field. The question of the practical use of these micro-organisms—these disease-germs—as insecticides is a very fascinating one, and is much written about just now; but unfortunately it proves most alluring to those who have had the least practical experience in coping with injurious insects in the field, and is much more apt to assume importance to the closet theorists than to those who, from experience, are conscious of the difficulties involved in its applicability.

Chapters XI, XII, and XIII treat of the machinery and mechanical devices which are in use or may be used for the destruction of the insect, whether direct or by facilitating the application of the various substances treated of in Chapter X. No excuse need be offered for the relative length of these chapters, as, owing to its importance, by far the larger part of the time and means employed in the investigation has been given to this part of the subject. In the early part of the investigation we personally took pains to acquaint ourself with all that had been done in this direction, and studied not only the patents that

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had been issued for machinery to be used against the Cotton Worm, but more particularly such as was actually in use in the field. A summary of the results was given in Bulletin 3 of the Commission. The variety of these inventions by Southern planters and the ingenuity displayed in many of them compared very favorably with what had been done in similar directions in other parts of the country, and two important facts were obvious and are worthy of emphasis:

First. Though there is every reason to believe that the ravages of the worm were proportionally as great before as they have been since the late war, yet all the more important inventions post-date that period. Prior thereto only the more primitive and ineffective means of destruction, such as hand-picking and the use of fires and lights in the fields at night, were resorted to.

Secondly. By far the greater number of the machines have been invented in Texas, and this is doubtless due to the circumstance that the worm occurs more regularly and more disastrously there than in other States. Both facts are indicative of the more healthy development of the South under free as compared with slave labor.

The more satisfactory machines in vogue were those which distributed the liquid poison in broadcast spray or sprinkle over the surface of the plants from some wheeled vehicle containing a reservoir for the liquid, which was either distributed automatically or by means of force-pumps. We soon became convinced that whatever improvements were possible must be, as indicated in our later instructions to agents, in the direction of spraying the under surfaces of the leaves and of reducing to a minimum the quantity of poison necessary to an acre, as also the labor necessary to apply it.

The more important of these aims was first foreseen by Mr. W. J. Daughtrey, of Selma, Ala., who, in February, 1878, in his letters patent (see pp. 258–9), fully realized the advantage of fine spray on the under side of the leaves. Although the very ingenious machine contrived by him and described in these chapters did not work as successfully as he had hoped, and was too elaborate, heavy, and expensive to prove practically successful, yet too much praise cannot be given Mr. Daughtrey for the clear manner in which he saw what was required and the skill with which he endeavored to put the principle to practice. It has been our aim in this part of the work to develop simpler means, that may be available to the average planter for attaining the same object, and we would more particularly call attention to the underspraying arrangements described on pp. 288–293 and supplemented in Note 52. In order to accomplish anything of value in this field of machinery, it was necessary that some competent person should be able to devote his entire time to carrying out our ideas and to such experimentation as the objects in view suggested or required. Experience had shown that a professional engineer was not best fitted for the work, and we were finally fortunate in securing, in the summer of of 1880, the services of

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Dr. Barnard, who, in addition to his knowledge of natural history, possesses mechanical ingenuity of a high order. After giving some time to general observations in Mississippi and Alabama in the summer of 1880, he was called to Selma the latter part of August, and charged with mechanical work. It was there and early in September that the cyclone-nozzle originated in our endeavors to contrive something that would throw a spray from the ground up. The question was discussed between us as to whether water forced tangentially into a flattened disc would rotate and issue from an outlet in a straight or in a spreading jet. Dr. Barnard took the latter view, and a disc, improvised by means of two watch crystals, so as to permit the motion of the liquid to be seen, proved that he was correct. The size and form finally adopted is the result of numberless subsequent experiments covering a period of nearly two years.

While we have always had a number of original ideas to carry out and our direction of this work has been active, yet Dr. Barnard's assistance was fertile from the first, and there is so much that has resulted therefrom that the preparation of these chapters was finally assigned to him, and he deserves much of the credit that attaches to them. It was found expedient, on account of the large increase of matter, to depart from the general arrangement adopted in the first edition, which, while it had the merit of simplicity, did not permit of so thorough a classification. Much of the material in that first edition, is, however, used verbatim in these chapters and such is placed in quotation marks, so that any quoted passage without authority or credit may be understood as being from that edition.

In describing these various machines and contrivances, it has been the endeavor to bring to the notice of the planter all that are worthy of mention, and to point out their advantages and disadvantages and how they may be used most economically and effectively. The planter can then judge for himself which he can most profitably adopt according as his own circumstances dictate. Many of the older machines and contrivances are thus mentioned or described (though now superseded by improved ones) because they are of interest from a historical point of view.

Chapter XIV gives a short account of the history of the literature on the Cotton Worm and closes with a bibliography up to and including the year 1881.

In Chapter XV are illustrated and described some of those insects which either in the larva state, but more particularly in the imago state, are liable to be confounded, and in fact have often been confounded, with the true Cotton Worm. As the northern Army Worm (*Leucania unipuncta*) in the imago state is, from its color and frequency, most often thus mistaken in winter time, we have introduced a colored plate of the species to facilitate comparison.

Chapter XVI is devoted to the Boll Worm, and will be found to con-

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tain a quite full account of it, especially of its different food-plants other than cotton; of its habits, characters, natural history, and natural enemies. A summary of its distinguishing points as compared with Aletia; a full consideration of the different methods that are available to counteract its injuries, and a bibliography are also given. It is fortunate that the best methods of underspraying the leaves of cotton with poisons to destroy the Aletia also prove, all things considered, the best means of preventing the injury to cotton of this Heliothis.

Finally, in the Appendices will be found such reports from agents and observers as have been deemed worth publishing as supplementary to the report proper. The tabulated replies to the first circular issued from the department are not included, as they were published in the Department Cotton Insect Report, while the more valuable of those in reply to Circular No. 7 are given in Appendix VII. As already stated, these Appendices include also Mr. Branner's report on observations made in Brazil, as well as the reports from consular agents upon the insect in other countries.

The Notes, as already stated in the Preface, either contain matter of a technical nature that it was deemed advisable to exclude from the main text, or matter needed to still further elucidate or supplement it.

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CHAPTER I.

CLASSIFICATION AND NOMENCLATURE. DESTRUCTIVENESS.

POPULAR AND SCIENTIFIC NAMES.

Among planters the Cotton Worm is very often termed the "Caterpillar," or the "Cotton Caterpillar," and not infrequently the "Army Worm." We have elsewhere shown* why this last term should be discountenanced in the literature of the subject, unless prefixed by the word "Cotton," and, both for the sake of brevity and to prevent confusion, the name used in this Bulletin, and by which the insect in this larva state is very generally known, is, on the whole, preferable. In Louisiana, more particularly, the French term "chenille," meaning caterpillar, is commonly employed. For the perfect insect the term "fly" is more often used in some parts of the South than the term "moth," but the latter is preferable from an entomological view.

As to the scientific name, the species was first described by Thomas Say, in 1827, as *Noctua xylina*, in a letter to Dr. C. W. Capers, published in the *Southern Agriculturist* (vol. I, p. 203), but overlooked by most later writers. Harris, in his Correspondence, placed the "Cotton Moth" near the genus *Ophiusa*, while later authors more correctly referred it to Hübner's genus *Anomis*. Mr. A. R. Grote, in 1874,† arrived at the conclusion that Say's *xylina* was nothing more nor less than the *Aletia argillacea* of Hübner, described and figured by this author in 1823[1]. In this opinion he was followed by subsequent authors, and this name was adopted in Bulletin 3 of the Commission, and also in the Special Report of the Agricultural Department. Recent studies,[2] however, indicate that, although our Cotton Worm moth is found at Bahia, the locality from which *A. argillacea* was originally described, this name was, without much doubt, given by Hübner to an entirely distinct species also found in the same locality, and Say's specific name of *xylina* should still hold for our Cotton Worm moth.

Accepting the difference between *Anomis* and *Aletia* as of generic value, our Cotton Moth should still be placed in *Aletia;* and the common or popular name "Aletia," which we proposed in the Bulletin, and which has come into quite extensive use in the last four years, may, therefore, be retained.

* See Second Annual Report on the noxious, beneficial, and other insects of the State of Missouri, 1870, p. 37.

† Proc. Am. Assoc. Adv. Sci. for 1874, 1875, v. 23, Sec. B, p. 13–18.

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We may briefly give the corrected synonymy of the insect as follows:
Noctua xylina Say, 1830.
Ophiusa (?) *xylina* (Say), Harris, 1851.
Anomis grandipuncta Guenée, 1852.
Anomis bipunctina Guenée, 1852.
Depressaria gossypioides Wailes, 1854.
Anomis xylina (Say), Grote, 1864.
Aletia argillacea Hübn., Grote, 1874.
Aletia xylina (Say), Riley, 1881, 1882.
Aletia xylina (Say), Brooklyn Society Check List, 1882.
Further particulars will be found in the Notes and in chapter XIV, which treats of Past History and of Bibliography.

CLASSIFICATORY POSITION.

The Cotton Worm moth belongs to that order of insects known as the LEPIDOPTERA, which includes all true butterflies and moths. The moths (*Heterocera*) are separated into a number of families, of which the Owlet Moths (*Noctuidæ*) form one of the most important. This family *Noctuidæ* is of great interest to the economic entomologist, for it contains not only the insect under consideration, but all the true Cutworms, the Army Worm, the Grass Worm, the Boll or Corn Worm, the Cabbage Plusia, and many others of scarcely less importance.[2a]

DESTRUCTIVENESS OF THE WORM.

An impartial calculation of the money loss to the cultivator caused by injury to the great staples of the country from their insect enemies, is sure to startle us by its magnitude when the loss is aggregated. Such a calculation of the losses which the Cotton Worm (not to speak of other insects) inflicts on the people of the South, based upon the somewhat imperfect statistical data at command, leads to the following interesting conclusions, which for the most part receive explanation in the facts embodied in this report. The calculation embraces fourteen years after the close of the civil war, and was made by Mr. C. R. Dodge, and verified for us by Mr. J. R. Dodge, the statistician. Any extraneous causes which tend to retard the growth of the plant, also tend to swell the percentage of injury by the worm when it abounds. Where an early stand is secured, with thorough cultivation and exemption from other causes of injury, there the percentage of loss is least, even in bad Cotton Worm years. The percentage of loss is, also, dependent on location. When the injury is done early in the season, the loss in localities of heaviest production, or where the fields are numerous and contiguous, is nearly double what it is where the fields are more isolated. In years of severe injury, from 30 to 98 per cent. of the crop may be ruined upon some plantations, while on others the loss will be trifling. The highest average of loss is sustained in the southern portion of the belt, as in Florida and southern Texas. It increases also in a westerly direction,

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commencing with Georgia at 16 per cent., or 16 bales out of every 100 of an average crop for fifteen years, and ending with Texas at 28 per cent. In the northern portion of the belt the averages are low, ranging from 5 to 8 per cent. for the same period; while in many parts of it, and notably in North Carolina, the worm appears so late as to generally do more good than harm by removing the luxuriant top foliage, and thus admitting the sun to the lower bolls and hastening their maturity.

The following table shows the amount of loss in bales and dollars for each State in a year of severe visitation:

State.	Per cent. of loss for worst years.			Crop.	Losses.	Money loss.
	Highest.	Lowest.	Average for State.	Average number of bales for 14 years.	Average number of bales for worst years, in round numbers.	For worst years at $50 per bale.
Florida	.....	.....	24	49,700	12,000	600,000
Georgia	25 1	15	16.5	474,600	78,422	3,912,000
Alabama	25.2	12.5	17.8	536,700	95,790	4,789,000
Mississippi	24	15	17	706,000	123,070	6,150,000
Louisiana	.....	.....	20	438,700	89,740	4,437,000
Texas	35	20	28	525,000	148,125	7,406,000
South Carolina	.....	.....	05	224,500	11,225	560,000
Tennessee	.....	.....	05	147,000	8,365	418,000
Arkansas	.....	.....	08	347,000	27,760	1,380,000
North Carolina	.....	.....	.....	.....	.....	.....
Totals	.....	.....	17.2	3,449,200	594,497	29,711,000

The terms "highest" and "lowest" in this table do not refer to the greatest amount of injury or to the reverse inflicted in individual localities, but to a general average for the principal counties of heaviest production on the one hand, and the average for the remainder of the State on the other. These figures are derived from the statistical reports of the Department of Agriculture. The average for the State as a whole appears in the third column, made up from the same sources. The fourth column is made up from reports of the cotton movement. The table shows a possible loss, in years of great prevalence, of about $30,000,000. On this basis the average annual loss may safely be put down at about $15,000,000 for all the cotton States for the fourteen years following the war.

There have been two previous estimates of the loss occasioned by the worm, both of which bear out this table. In the report of the Statistician of the Department of Agriculture for 1877 the loss by the cotton worm was estimated for that year at $15,000,000, the greater portion of the loss being suffered in Texas, though the damage was considerable as far east as Alabama. Notwithstanding this loss the year was one of unusual harvest, hence this estimate bears out well our estimate of the average annual loss. In the report of the Entomologist in the annual report of this Department for 1873 (p. 164) there appears a general

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statement, also furnished by the statistician, which placed the amount of damage at possibly 500,000 bales in years of insect prevalence. This, at $50 a bale, would be $25,000,000, also closely approximating our estimate of the damage in worst years. The estimate of price at $50 a bale for the fourteen years succeeding the war is low rather than high, as the plantation prices between 1860 and 1870 ranged from $180 down to $60.

That the damage was equally great before the war there is no reason to doubt, for while severe visitations have, perhaps, been more frequent since that time, the injury has been greatly diminished by the use of Paris green and other arsenical poisons since the year 1873.

The subsidiary table of losses from the worm for the year 1881 illustrates this point quite well:

Loss of cotton by worms as reported in 1881.

States.	No. counties reported.	Loss.	Total, per census.	Loss.
		Bales.	*Bales.*	*Per cent.*
Alabama	46	51,349	509,616	10.1
Arkansas	45	15,055	407,342	3.7
Florida	16	4,077	29,623	13.8
Georgia	93	20,958	582,332	3.6
Louisiana	29	29,649	273,356	10.8
Mississippi	39	38,111	583,763	6.5
Missouri	6	.....	16,135	.....
North Carolina	56	204	346,231	0.1
South Carolina	25	10,233	413,943	2.5
Tennessee	28	1,374	146,150	0.9
Texas	88	22,472	561,778	4
Virginia	4	.....	7,800	.....
Total	.....	193,482	3,878,769	5

Total cotton produced, 6,589,000 bales; total cotton produced in counties reporting worm, 3,878,796 bales, or 58.9 of the whole crop. This would leave on the basis of the whole crop a loss of only 2.9+%, or a money loss of $8,706,690, calculating on $45 the bale, or $9,674,100 on the former basis of $50. We would especially call attention to the great reduction in the percentage of loss from 17.2 to 2.9+.

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CHAPTER II.

CHARACTERS, HABITS, AND NATURAL HISTORY.

[Plate I.]

The Cotton Worm, like most other insects, and all belonging to its Order and Family, exists in four distinct states, which differ much from each other. They are, 1st, the *egg;* 2d, the *larva* or worm; 3d, the *chrysalis;* 4th, the *imago* or moth.

The worm MUST hatch from an egg deposited by the female moth. All theories to the contrary, such as its supposed spontaneous development from the plant, or its origin from the cotton-seed, are therefore utterly without foundation. They need emphatic denial here, because of their prevalence not only among the negroes and the more ignorant, but among intelligent men unfamiliar with the principles of biology. Such theories always have been, and doubtless always will be entertained in explanation of the apparently sudden appearance and rapid multiplication of any insect or other organism in which the preliminary phases of the phenomena are easily overlooked or with difficulty traced. We will indicate the characteristics of these four states, so as to enable the reader unacquainted with any or all of them to recognize the species in any phase of its growth and to distinguish it from all other insects, and will give detailed descriptions of the different stages elsewhere.[3] On Plate I, more particularly, we have represented, of natural size, all the different phases, as they may be observed in the field.

THE EGG.

The egg is 0.6^{mm} wide, circular, much flattened and ribbed, as at Fig. 1. Of a bright bluish-green or sea-green when first laid, it contrasts sufficiently with the warmer green of the leaf to be easily detected, even by the naked eye when practised (Plate I, Fig. 1). It is laid singly, and fastened with such firmness as not to be easily removed without injury. It is laid by preference, during early summer, on the under side of the larger and lower leaves, and seldom more than three or four are found on one leaf. In confinement and exceptionally in nature it will be laid on the upper surface of the leaf, or on any other exposed part of the plant. In autumn, more particularly, the upper leaves receive a due share of the eggs, and we have

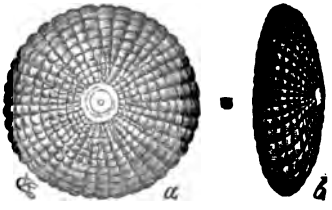

FIG. 1.—EGG OF ALETIA: *a*, from above; *b*, from side. (After Riley.)

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counted as many as 49 eggs and egg-shells on a single leaf. With development the color becomes more dingy, or pale yellowish, frequently with brownish borders or a green curve, due to the coiled embryo, which may be seen through the transparent shell. The young worm or larva eats its way out through an irregular hole on one side, usually during the morning, ere the dew is dissipated, and from three to four days after oviposition. This is the average time elapsing between the laying of the egg and the hatching of the worm therefrom in ordinary midsummer weather, but the time varies with the temperature, and a much longer period is required in spring and late autumn.

All eggs perish that are unhatched when overtaken by frost, as is not infrequently the case. The vacated and glistening shell is more readily noticed upon the green background than the unhatched egg. At Fig. 1 we have shown one of the more perfect eggs both from above (*a*) and from the side (*b*), and greatly enlarged, so as to indicate the sculpture, the natural size being indicated between them.

Humidity seems to favor hatching. Aphides or plant-lice are quite often mistaken for the eggs of this insect, while the "Mealy-bug" (*Dactylopius* sp.), a species of *Aleurodes*, the eggs of the Lady-birds (*Coccinellidæ*), those of the Lace-wings (*Chrysopa*), and even a minute snail, not uncommon on the cotton plant, are likewise so mistaken.

THE WORM OR LARVA.

This, as it appears in its different stages of growth on Plate I, is familiar to every planter. Varying greatly in ground-color, it is characterized by the particular position of the black piliferous spots upon the head and upon the body; by the white ring which surrounds each of these spots; by its pure white subdorsal lines and by its elongate and slender form. It is a semi looper, the first pair of prolegs being very much reduced in size and seldom used, and the second pair, though longer, only about half as long as the succeeding pair.[4]

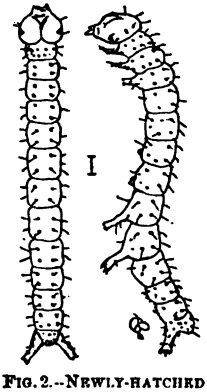

FIG. 2.—NEWLY-HATCHED COTTON WORM: *a*, back; *b*, side view. (After Riley.)

The worm molts five times during growth and changes appearance but little after the first molt. Exceptionally only four molts are suffered.

The newly-hatched worm measures 1.6^{mm}, is of a uniform, pale dingy yellow, marked as in Fig. 2, with polished, black, slightly elevated spots, each bearing a short, pale hair. Before the first skin is shed the color often becomes slightly greenish and sometimes inclines to orange. After the first molt the piliferous spots are more conspicuous, the hairs from them longer and black, and the characteristic markings appear, though less distinctly than after the second; but from this time on the prevailing color is very variable, being either entirely of various shades of pale or pea-green, or more or less intensely black along the back.

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The normal number of larval molts is five. This is the number which we have observed during the autumn months, while in midsummer, when the development is more rapid, we have on several occasions traced but four. The term of larval existence varies from one to three weeks.

There is a very general belief among planters that the first worms of the season are pale and the late ones dark, and while both light and dark worms may always be found together in spring, summer, or fall, it is true that the green ones predominate early in the season and the dark ones later.[5]

Immediately after molting, the body is pale and without marking—a rule with all molting animals. After the earlier molts, the cast-off skin which remains more or less fully stretched, is sometimes eaten.

Some of the peculiarities in the habits of the worm deserve mention here, because of their practical bearing.

Until after the second molt it always remains on the under side of the leaf, feeding upon the parenchyma, and leaving untouched the coarser veins, stomata, and upper skin or epidermis. The leaves where they are thus feeding present a blotched appearance, the semi-transparent epidermis becoming pale yellowish, and these blotches are, as a rule, at once distinguishable from other somewhat similar ones made by a few other insects.[6]

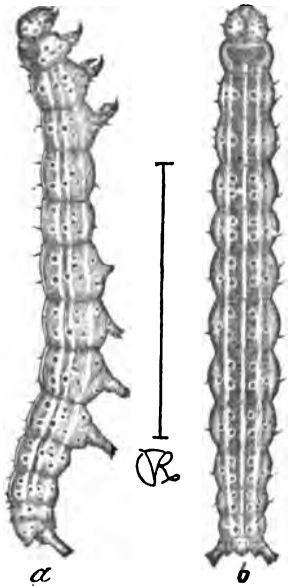

FIG. 3.—FULL-GROWN COTTON WORM: *a*, from side; *b*, from back; twice natural size. (After Riley.)

After the worm begins to eat entirely through the leaf, which is usually before the third molt, but sometimes later, it instinctively ascends toward the top of the plant and feeds on the more tender foliage, "ragging" it, to use the expressive language of the planter.

It can let itself down by a web from the moment of birth, but can also fling itself from one part of the plant to another in a manner quite characteristic. The fling or jump is made by bending the fore and raised part of the body to one side and then suddenly jerking it to the opposite side, relaxing meanwhile the three hind pairs of legs by which it held to the plant. This is a quite common mode of motion when disturbed, and the normal way of getting from one plant to another. The maximum distance which a worm can thus jump in a horizontal direction is about two feet, and it almost invariably alights on its legs. During chilly weather in autumn this motion is feeble and can be easily watched. When not feeding, the worm either rests stretched straight on some part of the plant or may be seen swaying its fore body from side to side, holding the while by the hind prolegs.

Though preferring the foliage, it will, when hard pushed, eat every

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exposed part of the plant, even barking and girdling the stems. In feeding on the bolls, however, it does not bore like the Boll Worm (*Heliothis armigera*), but eats the external parts as well as their contents. It is not known to thrive on any other plant than cotton, although probability points to the belief that there will yet be found one or two more such food-plants, both at the North and at the South.[7]

As one correspondent naively puts it, "the worms feed only on cotton and one another," the cannibalistic propensity being freely indulged when the occasion presents. It is a common remark that the presence of the worm is easier detected by smell than by sight. The planter says that he can "smell the worm." There is a peculiar odor arising from the excrement, but particularly from the gnawed and mutilated leaves, that gives rise to this saying; but where the worms are numerous and large enough to render it obvious, there they have already existed several days, perhaps weeks, in smaller numbers.

When numerous enough to utterly defoliate a field before they have attained full growth, the worms will travel in all directions on the ground, and they have been exceptionally known to collect together and travel in vast bodies in their search for fresh food.

THE CHRYSALIS.

Having obtained full growth, the worm, in the language of the planter, "webs up," forming for protection a more or less perfect cocoon, usually within the fold or roll of a leaf sparsely lined with silken meshes. Here it contracts and thickens, the distinctive marks are nearly obliterated, and the green color acquires a verdigris hue. Within twenty-four hours, in midsummer, the skin splits just back of the head, and is gradually worked to the end of the forming chrysalis, now soft and green, but acquiring in the course of an hour or more a brown color and firmer consistence. This chrysalis state lasts, on an average, about a week in hot weather, but may extend to thrice that time with lower temperature. Where necessity obliges, the worm will spin up on any other plant or in any situation that offers shelter. In confinement it will make a cocoon on the surface of the ground, covering and disguising the same with particles of earth, or it will even transform on the ground without silk or shelter. Such cases rarely if ever occur in a state of nature, but when the worms are very numerous in a field the chrysalides frequently have their leafy protection eaten away, so that many of them either hang by the few hooks at the extremity, or fall to the ground. In no case, however, does the worm burrow in the ground as does the Boll Worm, or could the moth issue from the chrysalis were the latter accidentally buried even an inch beneath the surface.

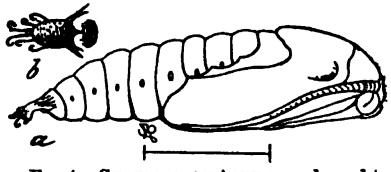

FIG. 4.—CHRYSALIS OF ALETIA: enlarged to show cremaster from the side (*a*) and from beneath (*b*). (After Riley.)

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We shall presently see, in discussing the hibernation of the species, that it is quite important to distinguish between this chrysalis and others that closely resemble it, and to enable the reader to more readily do so an enlarged outline is here introduced. The color varies from light mahogany-brown to deep purplish-brown, while the general form is that belonging to many other chrysalides. Neither form nor color can serve, then, as distinguishing traits, and the same is true of size. The peculiar form of the cremaster, or anal tubercle bearing the hooklets (Fig. 4), will prove the best and safest criterion, and any chrysalis found in a cotton field that has a different tip may be safely determined as not that of the Cotton Worm. The duration of the chrysalis state also averages about fifteen days. We have known it to last but seven days, and Mr. Glover records its lasting thirty days.*

THE MOTH, OR IMAGO.

The moth measures from 1⅛ to 1½ inches from tip to tip of wings when these are expanded. Its general color, above, is olivaceous, more or less effectually subdued by lilaceous or purple hues, and often having a clay-yellow or faintly golden cast. The under side is more gray, with nacreous reflections.

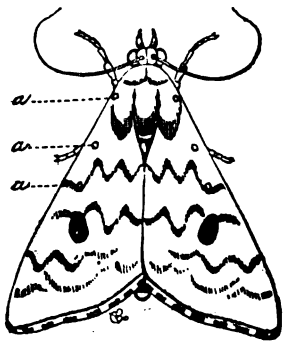

FIG. 5.—OUTLINE OF ALETIA: showing characteristic marks and white specks (*a a a*)—twice natural size. (After Riley.)

The markings that more particularly characterize and distinguish it from all other North American moths are certain undulating vinous or carmine lines across the front wings, a dark oval spot near their disc, containing pale scales which usually form a double pupil (the basal or inner pupil the smaller and whiter), *and three white specks dividing the space between this dark spot and the shoulder in about three equal parts.* (Fig. 5, *a a a.*)

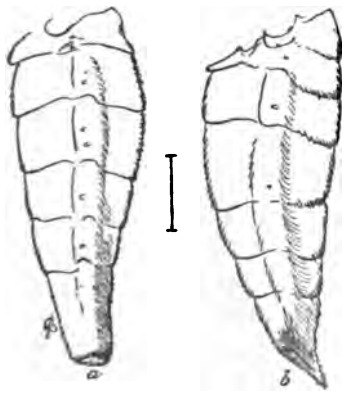

FIG. 6.—COTTON MOTH: *a*, male abdomen; *b*, female do.—enlarged. (After Riley.)

The sexes are not readily distinguishable, as the relative stoutness of the male antennæ compared with those of the female is so slight as to be no safe guide. An examination of the tip of the abdomen, especially from the side, will always show the difference, however, the last joint in the male (Fig. 6, *a*) being the longer and more full, and the pale tufts of hair that belong to the withdrawn genitalia[8] showing within or beyond the squarely docked tip; while in the female (Fig. 6, *b*) this joint is shorter, more pointed, and obliquely truncate beneath.

*Report of Commissioner of Patents, for 1855; Agriculture, p. 73.

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The habits of this moth can only be studied at night, as, like almost all the rest of its family, it is nocturnal. During the day it simply starts up when disturbed, and darts by swift and low flight to some other sheltered spot a few yards, or perhaps rods, away. After sunset, however, it may be seen leisurely hovering about, either bent on the perpetuation of its kind or feeding upon whatever sweets it can get, whether from the cotton or from other sources. It is very strong and swift of wing, and capable, when the necessity arises, of flying long distances. In alighting upon the plant it generally turns its head downward, and, when it rests, the wings are but shallowly roofed, the front ones closed along the back and fully hiding the hind ones. In this respect it may always be distinguished from the parent of the Boll Worm, which rests with the front wings partly open and not entirely covering the hind ones.

The female begins to lay her eggs in from two to four days after issuing from the chrysalis, the time varying with the different generations and according to temperature.

In experiments which we have made with moths confined in vivaria, eggs have sometimes been laid thirty-six hours after issuing, and the moths have continued laying for twenty-one nights, the number laid each night ranging from 4 to 45.

Examination of the ovaries of females at different seasons shows a much greater prolificacy than belongs to most moths, as the number of well-developed ova may reach 500, and of potential ova half as many more. In confinement it is difficult to obtain from one female more than 300 eggs, but that fully double this number are produced in the field during the height of the season there can be little doubt, while the average number may be estimated at about 400.

The natural food of the moth, as we first indicated in the fall of 1878,* is the sweet exudation from the glands upon the mid-rib of the leaf and at the base of each lobe of the involucre of the cotton plant.[9] Nevertheless it is attracted to all kinds of sweets, and in most parts of the South it finds a bountiful supply in the exudation from the spikes of *Paspalum lævе*, a tolerably common grass, but particularly in that copiously secreted by glands at the apex of the peduncle just above the pods of the Cow-pea (*Dolichos*). In the spring of the year, as Judge Bailey, of Marion, Ala., has observed, it may often be seen in the evening feeding in numbers, first from the blossoms of the Chicasaw plum, and subsequently from those of the peach, Chinese quince, mock orange (*Cerasus carolinensis*), the early apples, and blackthorn. Later in the season, when the glands above mentioned begin to exude and the tree blossoms are no more, the moths do not seem to be attracted by other nectar-storing flowers, since observations in different Southern States by ourself and assistants have resulted in finding but one species of verbena (*Verbena aubletia* L.) frequented, even where both moths and all sorts of

* See *Atlanta* (Ga.) *Constitution* September 20, and *Scientific American* November 15, 1878.

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flowers were abundant. But fruits of all kinds as they ripen are resorted to, and figs, apples, peaches, plums, apricots, grapes, persimmons, and even melons, are often greatly injured.

Carefully examined, the tongue is seen to be armed along its terminal half with stout and sharp spines projecting forward from the upper surface and increasing in density toward the tip, which is beset with them on all sides. It is by means of this spinous tip of the tongue that the moth works a hole in these fruits, and is thus enabled to absorb the more liquid portions. Apple pomace is especially attractive to them.

FIG. 7.—COTTON MOTH: *a*, with wings expanded; *b*, with wings closed. (After Riley.)

We have, in fact, been quite astonished at the perforating power of the proboscis as exemplified in the puncturing of hard, unripe pears. We have known such to be punctured quite deeply, the effect of the puncture being to soften and discolor the fruit for some distance around. The accompanying illustration (Fig. 8), which gives an enlarged view of the partly coiled proboscis and a still more highly magnified view of its tip, will explain more clearly than words its adaptation to such puncturing. The stiff and sharp spines are, in fact, admirably suited for rasping and lacerating the pulp and thus setting free its juice. This puncturing habit is possessed by several other moths, and notably by an Australian species (*Ophideres fullonica*), which is very injurious to oranges, and the structure of the proboscis of which has been well illustrated by Mr. Künckel.* A number of our own North American species of Noctuidæ likewise have the tip of the proboscis more or less spinose, indicating that they also possess the power of extracting juices from other sources than the nectaries of flowers.

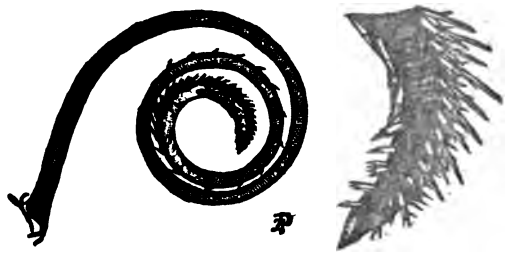
FIG. 8.—PROBOSCIS OF ALETIA: *a*, the coiled proboscis, magnified about 10 diameters; *b*, tip of do., more highly magnified. (Th. Pergande, *del.*)

TIME ELAPSING FROM ONE GENERATION TO ANOTHER.

This varies according to temperature, and therefore according to season. There is increasing activity and acceleration in development from the first appearance till July, and thenceforth decreasing activity and retardation in development till frost. Thus in midsummer the whole cycle of individual life, from the hatching to procreation, may occupy less than three weeks; while in spring and late autumn it may

* Comptes Rendus (French Academy), August 30, 1875.

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occupy twice that time. Taking the whole season through, however, the time from the egg of one generation to that of another will average about one month.[10]

TIME OF YEAR WHEN THE FIRST WORMS APPEAR.

Until the Cotton Worm investigation was begun, our knowledge as to the earliest appearance of the worms was not only vague, but misleading. The statement emphasized by Mr. Grote in the paper already referred to, namely, that the worm does not appear earlier than the latter part of June in the central portion of the cotton belt of Alabama and Georgia, very fairly echoes the prevailing popular belief on the subject; yet careful investigation shows the statement to be essentially erroneous. The date of earliest appearance varies with location, and largely with the curves of isochimal lines;[11] it also differs somewhat in different years in the same location, according as the season may be late or early; and, lastly, it may differ to some extent in different parts of the same restricted locality, worms having been found just hatching in one place when, only a few miles distant, others were found nearly full grown.

While these modifying circumstances complicate consideration of the subject, it is easy to arrive at definite results by taking as a basis observations made at a few particular points during the year. Hence we felt the importance of having such observations made during the spring of 1879 in South Texas and South Alabama at those places where the worm was reported to have appeared earliest in past years. As a result, the fact was fully established that the first worms of the season may, and do, in ordinary years, hatch from the middle of April to the middle of May in the southern portion of the cotton belt. And, moreover, all the facts showed that this season was a late one, for April frosts retarded the starting of cotton in those very sections of Alabama where the worms were first found; while it is the unanimous opinion of planters in South Texas, where the worms were first noticed, that cotton was from two to three weeks later in 1879 than usual. Therefore, when in the spring of 1882 we found the worms of all sizes on rattoon cotton during the latter part of March, in South Georgia and Florida, we were not surprised, although this was fully six weeks earlier than they had ever before been noticed or recorded.[12]

The first worms are always comparatively few in number and in isolated spots. They are, therefore, easily overlooked by all who do not take particular pains to search for them. From such spots as centers the worms multiply and spread in subsequent generations, with greater or less rapidity, according as the conditions are favorable or otherwise. Such increase and spread may be confined to some part of a given county until the cotton is nearly ruined before the cotton in the rest of the county is affected. The worms will then first appear in the remainder much more suddenly and numerously than they did in the former, the parent moths migrating thereto in bevies. As a rule, however, the spread in the southern portion of the belt is gradual and the worm in

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destructive numbers is preceded by one or more scattering generations in the same field.

Other things being equal, the worm must appear earliest in the southernmost latitudes, since extended observations on the appearance of other insects show that there is retardation of from four to seven days with each degree of latitude northward.[13]

There is, in normal seasons of little injury to the crop, a similar retardation northward in the appearance of the Cotton Worm within the southern portion of the belt, corresponding in some measure with the growth and development of the plant; and it is a notable fact that the worm is seldom noticed and never in great numbers before the plant begins to bloom. What is generally under these circumstances called the first brood or "crop" has been preceded by at least one and often two generations sparsely distributed over the fields. Yet in years when the worm abounds to a disastrous extent in the southern portion of the belt, its appearance in the northern or temporary portion cannot be counted on with any certainty as to time, because it is always the result of migrations in the winged state, and these migrations may be more or less extended according to circumstances. Between the first appearance of the worm in the southern and northern portions of the belt there is, therefore, a marked difference ordinarily observable, it being in the latter much later and in far greater numbers.

NUMBER OF ANNUAL GENERATIONS.

The general impression and belief that prevails in the South is that there are, in those sections where the worm is most injurious, three broods or generations, or, as the planter puts it, "crops," each year. This statement of the case has also been accepted as correct by most previous writers on the subject.[14] It is, however, essentially erroneous, so far as the southern portion of the cotton belt is concerned, as the earlier and later generations are not taken into account, but overlooked. The appearance of the first generation has already been discussed, and it occurs during the latter part of April and in May in the more southern portions of the belt, and even in March in Florida. One generation follows another continuously from that time on, just so long as there are any leaves to be devoured, and we have, by protecting both plant and insect from frost, kept the moths ovipositing in the city of Washington all through November; while the worms, under like conditions, have hatched through the early part of December, matured, and spun up about Christmas time.

Careful observations and experiments in 1879 in South Texas show that at least seven, and probably even more, annual generations are produced there. The first two generations are generally well separated, but, owing to the irregularity in egg-laying and in individual development, the later generations so cross each other, that the insect may be

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found in all stages in the same field at one and the same time. Yet the succession of broods may be recognized by the condition of the bulk of the specimens in the field or by confining the insects for the better watching of them.

The first generation, as we have seen, is confined to spots. The second generation is more dispersed, but still restricted to areas in the vicinity of the hibernating centers. The third generation of worms may become, under favoring conditions, not only widespread but disastrous, and the moths produced from them so numerous that they acquire the migrating habit. This generation appears in South Texas during the latter part of June, and in South Alabama and Georgia somewhat later. This is usually the supposed first brood in those sections, *i. e.*, the first which attracts general attention. The subsequent generations naturally become more and more widespread, and the increase during July and August, 1880, was noticeable in the face of meteorological conditions unfavorable thereto. The worms during these months will appear in those fields in which they did not appear earlier, as on sandy, elevated prairies, soils or lands where the growth of the plant was retarded from late planting, overflowing, the injury of the plant-lice, or whatever cause. If the weather be favorable, this August generation will, when unmolested, carry ruin in its wake. Did one generation follow another in the natural ratio of multiplication, such is the fecundity of the species that there would be no hope of profitably cultivating cotton. Fortunately for man, some of the earlier generations are liable to be so effectually kept in check by natural enemies and other adverse influences that they become innocuous and frequently escape notice. This fact was strikingly illustrated in May, 1879, in Colorado and Lavaca Counties, in Texas, where the second generation, which hatched in sufficient numbers in most fields to create alarm, nevertheless vanished before its enemies so completely that it was difficult, a little later, to find a perfect chrysalis.

That this second generation may exceptionally become very injurious is shown from records, to the effect that in the early part of June of the same year, while the cotton stem was yet tender, whole plantations in the low bottom lands of Louisiana have been eaten to the ground; but that it more often proves harmless is probable for various reasons. The plant-lice, which are apt to be very numerous on the very young cotton, partially disappear before their natural enemies by the time this second brood of worms is developing. The ants, which were previously supplied with food by the plant-lice, have now multiplied, and are forced, by the decrease of the aphides, to seek other food. They are consequently more effectual in destroying the young worms. All the other enemies of the worm are also more active during the month of June, and gregarious birds, like the blackbirds and ricebirds, are very common during that month, but generally leave the fields later.

In the northern portion of the cotton belt the number of annual gen-

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erations is, of course, fewer, and will vary according to the date of the incoming of moths from the further south, and according to other circumstances. The generations are not only fewer, therefore, but more easily separated and defined.

MIGRATIONS.

Many persons, noting the short and clumsy though rapid and darting flight of the moth, when disturbed during the day-time, get the idea that it is incapable of extended flight. But it has great power of wing, and its migrating habits are abundantly attested. It has been observed in numbers, far out at sea, and captured in autumn off the coast of New England, around Chicago and around Buffalo—the species being identified by competent entomologists like Packard, Burgess, Grote, and Westcott. We have known it to do considerable injury during September to peaches in Kansas, and to ruin acres of cantelopes during the same month as far north as Racine, Wis. That it is aided in these distant flights by favoring winds there can be no doubt, but that it does not depend on them for dispersion is equally certain. A factor to be considered, also, in connection with these northern appearances, is the probable existence of one or more northern food-plants.[15]

Dr. D. L. Phares records the destruction, by the worms, of cotton the first year planted, eighty miles from any point where cotton had been grown before; while Mr. H. P. Bee (see letter in Appendix) shows that they appeared in Mexico on cotton planted two hundred miles from any other fields. Numerous similar cases might be mentioned.

The migrating habit is common to many insects and other animals, but is almost always associated with excessive multiplication. Such is likewise the case with Aletia, as the observations of past years have clearly shown. So long as the worms are not numerous enough to materially riddle the cotton, the moths produced from them busy themselves with ovipositing in the neighborhood where they were born, spreading only comparatively short distances on all sides; but whenever the cotton is well "ragged," then the moths acquire the migrating habit and appear in numbers everywhere—in town and village, and at lights far away from cotton-fields. The time of year when this migrating habit is acquired varies, but it is rarely till after the third generation of worms, or the latter part of June and fore part of July in South Texas; while it is most pronounced during the autumn months. At such times the moths may be noticed, during cloudy days, starting off by rapid flight and ascending high in the air till lost to sight; and the contrast between this movement and the darting and hiding of the normal day-flight is quite striking to any one who has witnessed it.

HIBERNATION.

No question connected with the Cotton Worm has given rise to more speculation than that of the hibernation of the insect, and this fact at once finds its explanation in the difficulty that surrounds the subject.

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As partly illustrating this difficulty it will be well to elaborate the statements made in a paper read by the writer before the National Academy of Science at its meeting in Washington in the spring of 1879.

There are three principal theories on the subject that are worthy of consideration, and that are held by those with whom we have come in contact, or with whom we have corresponded. These are:

1st. That it hibernates in the chrysalis state.

2d. That it hibernates as a moth.

3d. That it does not hibernate in any part of our cotton-growing States, but comes into them on the wing from warmer climates where the cotton-plant is perennial.

Some few persons think that it winters in the egg state in cotton-seed or on the dead stalk of the plant; but such views may be disposed of by the statement that they are unsupported by even the appearance of fact.

At first blush it would seem easy enough to dispel whichever of these theories is erroneous and settle the question under consideration by a few simple facts of observation. The trouble is, however, to get at the facts.

About one-fourth of the intelligent people of the South hold the opinion that this Aletia hibernates in the chrysalis state, some believing that it does so above ground, others that it retreats beneath the surface of the ground. It has generally been stated by the writers on this insect that the chrysalis could not endure the slightest frost. We have been able to prove that it will suffer with impunity a temperature of from five to ten degrees below the freezing point, but that it cannot withstand a lower temperature; and all those chrysalides which do not give out the moth before severe cold weather sets in perish beyond any doubt. How easily men are misled even on this point, however, may be gathered from the fact that Dr. Anderson kept what he believed to be living specimens until after the severe cold of December. A careful examination proved that the lifelike motions of such chrysalides were due to the living pupa which they contained of one of the parasites (*Pimpla conquisitor*) presently to be described. The larger proportion of chrysalides that are not empty after a severe frost has occurred are infested with some kind of parasite, though many of them have perished from the effects of the frost and are either rotten or moldy.

Any number of intelligent planters insist that they plow up the chrysalides in spring, and the belief that the last brood works beneath the ground, out of reach of frost, is very firmly held by some of the most experienced cotton growers; but in every instance that has come to our knowledge the chrysalides thus plowed up have proved to belong to other species, most of them of the same family, and many of them having a sufficiently close resemblance to those of Aletia to confound any but the most skilled and experienced entomologist. As an illustration of the ease with which erroneous conclusions can be drawn

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from mistaken identity, we will here quote part of a letter received from Professor Willet, who has particularly interested himself in this subject. "I have received to-night," writes Professor Willet, "from Rev. Robert Harris, of Cairo, Thomas County, Georgia, a small tin box inclosing 25 chrysalides, which I forward you by mail. Mr. Harris is an ardent believer in the subterranean hibernation of the chrysalis of *Aletia argillacea*. I transcribe the portion of his letter pertinent to the case:

'CAIRO, GA., *February* 22, 1879.

'Washington's birthday and victory. *Perseverantia vincit.* The facts drive "analogy" to the wall. Here they are: 25 cotton-worm chrysalides ploughed up out of the ground in a field that was riddled by the insects last fall.

'This is unimpeachable evidence, and in the opinion of the court is amply sufficient to convict the prisoner.'

"The chrysalides," continues Professor Willet, "appear to my eye very like *Aletia* chrysalides which I have in spirits, and I await your verdict with interest."

The chrysalides referred to in this instance resemble those of *Aletia* so thoroughly in form, size, and general appearance that they might have been mistaken therefor even by some entomologists; yet, from certain minute structural differences, easily observable with a good lens, we were able at once to decide that they belonged to another insect, the *Aspila virescens* of Fabricius, a beautiful moth, with olivaceous primaries, marked with three distinct, pale, transverse lines, relieved by coincident deeper shades, the translucent green larva of which, speckled with minute, pale, fleshy elevations, we have found feeding on *Solanum sieglingo* in Saint Louis.[16]

There are many species of night-flying moths which go through their transformations beneath the ground, and there hibernate in the chrysalis state. The leaves of the cotton-plant are palatable to a very large number of such, while the Boll-worm (*Heliothis armigera*) and the "Grass-worm" (*Laphygma frugiperda*), which thus transform, are sometimes very abundant in a cotton-field. It is not at all surprising, therefore, that the chrysalides should be plowed or dug up in land planted to cotton. All of them, upon careful scrutiny, will be found to differ from the chrysalis of Aletia, which may be distinguished by its slender form, and particularly by the tip of the body with its armature, as shown in Fig. 4. In short, the nature of the Aletia chrysalis effectually prevents it from working beneath the ground, except where, dropping out of its cocoon, it happens to fall into some crack or crevice, and thus wriggle beneath the surface. It is also contrary to all analogy that a chrysalis normally found above ground in a cocoon should work beneath the soil; for all insects that pupate under ground descend while in the larva state.

Experiments which we have repeatedly made prove that the Aletia chrysalis, when placed under ground, either rots and perishes or the

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moth, if in a sufficiently advanced state when the chrysalis is buried, will vainly attempt to escape and push through its unnatural surroundings

Regarding the ability of the moth to survive the winter, nearly one-half of the more intelligent correspondents state that they have known the moth to be found flying during warm days in the winter, and that it consequently hibernates in that state. Mr. John T. Humphreys, of Morganton, N. C., who was for a while employed by the State of Georgia in entomological work, says that he has absolute proof of the hibernation of the moth.

Page after page of testimony and experience from the most competent and reliable planters might be adduced in support of the fact that the moth is to be seen either hidden in sheltered situations or flying during the milder weather of winter and in spring, in all of the southern portion of the belt. The situations in which it is most often reported as sheltering are under the shingles of gin-houses, under rails, and under the loose bark and in the hollows of trees and prostrate logs. In old pine stumps the sapwood separates from the heart-wood and forms excellent retreats for this purpose. The general hue of the large scales of pine bark is sufficiently close to that of the moth to make the resemblance protective. A dense forest of long-leaved pines also modifies and equalizes the winter temperature. These facts would lead one to suppose that pine forests offer unusually favorable conditions for hibernation, and Mr. Humphreys has, in fact, found the moth hibernating under pine scales, while some of our most reliable correspondents report having seen the moths sporting in great numbers in the edges of pine forests during the month of March.

Nevertheless, the persistent search by Mr. Schwarz in the winter of 1878–'79[17], under our direction, failed to reveal the moth under pine bark; whereby we were led to the conclusion that it seeks winter shelter some distance from the ground. It has been reported by some correspondents in greatest numbers in swamps of sweet gum, oak, magnolia, poplar, &c., such as are found in southern Alabama. These swamps are warm, moist, and miasmatic, and the moths are said to have been seen literally packed together in a torpid state in the hollows and burrows made in rotting logs by boring larvæ.

The evidence on this point of the hibernation of the moth would be overwhelming did it come from scientific observers; but, unfortunately, allied species are so often and so easily mistaken for Aletia that doubt still surrounds the subject. The liability to confound hibernating species is all the greater in that characteristic markings are more or less effaced or faded. The *Hypena scabralis* (Fabr.),[18] a moth belonging to a different group (*Deltoids*), and which hibernates in the imago state all over the country, is especially common in the Southern States, and large numbers have been sent to us as the genuine Aletia. It is nearly of the same size and form, and while normally of a darker brown, faded hibernating specimens are easily mistaken for the Cotton Moth because

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of undulating darker lines across the front wings, somewhat similar to those on the latter. Its palpi are longer and snout-like, and its front wings invariably lack the dark discal spot and the white specks characteristic of Aletia.

Phoberia atomaris Hübn.,[19] and many other similar moths, have been forwarded with the remark that they were the Cotton Moth; while *Leucania unipuncta* Haw., the parent of the Northern Army Worm, which feeds only on grasses and cereals, is everywhere found in the South during winter, and, on account of its great similarity in color to Aletia, and of a white discal spot relieved with a dark shade on the front wings, that heightens the general resemblance, is more often mistaken therefor than any other. It is more robust than Aletia, and a comparison of the accompanying illustration (Fig. 8) with Fig. 7, p. 11, will show the other differences. Seeing how easily non-entomologists are misled by general resemblances, we would again lay stress on the readily observed characters underlined on page 9, by which Aletia may always be recognized. Where they are absent it may be safely taken for granted that other species are in question. From this danger of confounding species it is evident that ordinary reports lose, when unaccompanied by specimens, much of their value, and must always be taken *cum grano salis*.

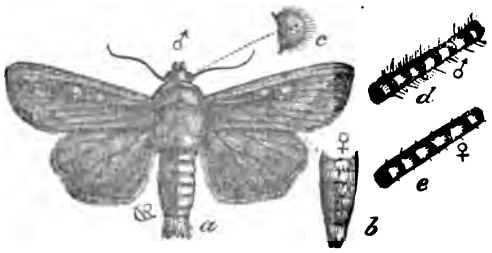

FIG. 8.—ARMY WORM MOTH: *a*, male moth; *b*, abdomen of female—natural size; *c*, eye; *d*, base of male antenna; *e*, base of female antenna—enlarged. (After Riley.)

Yet, after making due allowance for possible error, the number of intelligent planters with whom we have conversed, and who, having long and thorough acquaintance with the moth, feel positive of their ability to distinguish it and of having seen it during the winter, is so great as to leave little doubt of the fact; while the added testimony of Mr. Grote, who is such an authority on moths that he could not thus confound species, and who states that he has found the Aletia in Alabama during mild winter weather, should dispel even that little doubt; and we may safely consider as proven that the moth does survive the winter up to the end of March. The general experience of correspondents is, however, that after March these hibernating moths are no longer to be seen, and no one knows what becomes of them between this time and the appearance of the first worms.

The difficulty felt in bridging this gap, together with the progress of injury from the south northward, has given rise to the theory that the species cannot survive the winter in this country, and must necessarily come each year on the wing from some foreign country where cotton is perennial. The history of the repeated suggestions of this so-called migration theory, from Dr. Gorham's first article in 1847, down to

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Grote's paper before the American Association for the Advancement of Science, in 1874, we shall give somewhat in detail in Chapter XIV, but in this connection we may appropriately devote a brief space to the consideration of Mr. Grote's arguments:[20]

The principal arguments urged in support of the theory by Mr. Grote are [1] the *sudden* appearance of the moth in quantities; [2] the first appearance of the worms so late as the latter part of June; [3] the absence of parasitic checks; [4] the highly probable exotic origin of the species and its introduction into the States; and [5] the power of flight and migratory habits of the moth. The first three lose much of their force from the facts adduced in this report, since [1] in the southern portion of the belt[21] the sudden appearance is more apparent than real; [2] the worms appear in April;* and [3] they have numerous parasitic checks. There is also little force in the fact of original introduction from some foreign country, since most of our worst insect pests that are now acclimated and established with us were originally introduced from abroad; while [5] the migratory habit, as we have seen, is not developed in the first moths. Arguments urged by others in favor of the theory are [6] the periodical visitations and intervals of immunity; [7] the short life of the moth; and [8] the failure of those who have tried to keep it through the winter.

To these it may be replied that [6] many other indigenous insects abound during certain years and are unknown in others, and that these changes are due to the working of well-known laws; that periodicity in the appearance of Aletia is largely imaginary, because it either refers only to bad years and takes no stock of small numbers, or else is local. The investigations of the Commission show that the worm has been in some parts of the South ever since the civil war, and there is no reason to suppose that it was not annually to be found in fewer or larger numbers prior thereto. [7] The short life of the moth of the summer generations is no criterion for that of the last or hibernating brood, since any number of species which produce several annual generations and have but a brief span of life in the imago state in summer are known to hibernate in this state. [8] It is extremely difficult to attain, in a room, the proper conditions of moisture and freshness that belong to a sylvan atmosphere, and we have never been able to keep other Lepidoptera which hibernate in the imago state alive through the whole winter in such artificial situation, though we have tried with both *Danais archippus* and *Paphia glycerium*. For this reason it will always be next to impossible to get *absolute and incontrovertible* proof of the hibernation of Aletia by watching the moths from fall till they oviposit in the following year, but it may be truly said that if the hibernation of other species rested on equally absolute proof, there is not one among the Lepidoptera, or other Orders, for that matter, that could be said to hibernate. One other argument that has been made in favor of the theory may lastly be mentioned. It is that during the late war no cotton was grown for three years in some sections of the

* See further facts in Note 12.

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South, and that the first crop raised thereafter was infested. Professor Comstock took particular pains to make inquiries on this head, and found that some patches of cotton had been grown every year in such sections.

In favor of hibernation in the southern portion of the cotton belt may be urged [1] the appearance of the moth on the wing during mild winter weather, and its being found torpid in sheltered situations, as is insisted on by so many; [2] the first appearance of the worms in very small numbers, and in the spring of the year, as attested by recent observations; [3] their reappearance each year in the same spots, not on the sea-coast nearest to the tropical zone, where we should expect them on the theory of annual incoming, but at various points far inland; [4] the coming of the moths in large numbers and as immigrants into the northern portions of the belt, being always preceded by the appearance of the worms and their gradual increase at some other, generally more southern or western, points; and [5] the decrease of cotton culture in Central America and the West Indies, as appears from market statistics, and the absolute absence of the worm in the Bahamas since 1866, as ascertained by Mr. Schwarz while there in the spring of 1879.

The strongest fact against hibernation was, perhaps, the period elapsing between the disappearance of the moths in March and the first appearance of the worms, or, to put it in another form, the absence of the worms on the young and tender cotton. The period during which the species was not observed is already reduced by the facts given in this report to less than one month instead of three, and this is much less than the time elapsing between the issuing from winter quarters of other well-known Lepidoptera that hibernate in the imago state, and the first appearance of their larvæ, numerous illustrations of which fact might be cited.*

On the whole, therefore, the weight of evidence is strongly against the theory of annual extermination, in the southern part of the belt, and the fact of the hibernation of Aletia there may be said to rest on as good evidence as that of many other species in which it is admitted without question. Yet Aletia is beyond doubt killed out each winter in the northern portion of the cotton belt, and all the arguments in favor of annual extinction and incoming *de novo* have force when restricted to this section. Just where the separating line lies between extinction and survival is not so easy to decide, and for the present we can only refer to that given in the Introduction as the result of the investigation so far as it has gone. This conclusion that the moth does and can hibernate in the United States does not preclude its occasional incoming from foreign, more tropical countries, or the possibility of its being brought by favorable winds from such exterior regions, just as originally must have been the case when the species was first introduced. The facts indicate, however, that this kind of immigration is less frequent now-a-days than it was in the beginning of the century.

* The intervening period is still further lessened, as will be seen from the remarks on page 12 and in Note 12.

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To sum up the evidence from present knowledge: Aletia never hibernates in either of the first three states of egg, larva, or chrysalis, and it survives the winter in the moth or imago state only in the southern portion of the cotton belt. Our own investigations since 1878 in every cotton-growing State in the Union, together with the experience and testimony of both correspondents and special agents employed in the investigation, confirmed us in these conclusions, and we were consequently perfectly prepared for their justification by the facts obtained during the winter of 1881–'82. During this winter we were able to obtain the moths during every month, and watched them in fact until the early part of March. In short, there is nothing more fully established now than that the moth hibernates principally under the shelter of rank wire-grass in the more heavily timbered portions of the South, and that these moths begin laying on the rattoon cotton when this is only one inch or so high.*

1. It is quite certain that by far the larger portion of the moths from the last brood of worms perish in various ways without perpetuating the species. All those which fly north of the cotton belt must needs thus perish, as doubtless do all those that attempt to hibernate in the northern portion of said belt. The evidence is strong that even in the hibernating portion of the belt only the exceptional few, more favored than the rest and remaining steadily torpid till early spring, survive to beget progeny. Those which are aroused to activity during the mild winter weather spend their force without finding compensating nourishment, as there are neither fruits, flowers, nor sweet-secreting glands at that season wherewith to break their long fast and sustain vitality. It is for these reasons that the worms are generally less injurious after mild and changeable winters, and most to be dreaded after severe and steady ones, and it may very justly be argued, that did the larger proportion of the moths survive, there would be no chance to grow cotton. Like perishing of the bulk of most insects that hibernate above ground is, in fact, an acknowledged rule in entomology.

2. The localities where Aletia doubtless hibernates, and where, consequently, the earliest worms appear, seem to be more common in the western parts of the cotton belt than in the Atlantic States. Since the civil war the almost complete abandonment of cotton cultivation on the sea islands of the coast of Florida and Georgia has evidently reduced the number of favorable hibernating localities there, and in so far protected the more northern or western portion of the Atlantic States from the immigration of the moth from those quarters. In Texas, on the contrary, the cultivation of cotton has been constantly increasing since that time, and consectaneously the number of hibernating points and the risk of serious harm there over extended areas have also increased.

* See abstract of paper read before the National Academy of Sciences at Washington, May, 1882; also Annual Report, Department of Agriculture, 1881–'82, p. 166.

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CHAPTER III.

PAST HISTORY OF THE COTTON WORM IN THE UNITED STATES.

CHRONOLOGICAL ACCOUNT OF APPEARANCES AND OF YEARS OF MARKED PREVALENCE.

We have been unable to find any record of the appearance of the Cotton Worm in the United States prior to the oft-quoted statement of Spalding's,* that in 1793 "the destruction was complete. In Major Butler's field of 400 acres but 18 bags were made." From this time till 1800 no mention has been made of the worm; but in that year the crops in South Carolina and Georgia suffered severely. Dr. Capers,† and also Dr. Phares,‡ give 1800 as the first appearance of the worm in South Carolina; but there is a published statement of Mr. J. W. Grace§ to the effect that the Georgia invasion of 1793 extended to that State.

1804 was a marked year, and we always find it referred to in the older papers on the worm. In this year the Gulf States suffered for the first time. Louisiana, which grew more cotton than any other State, suffered severely. The crops on many plantations were entirely destroyed; but the caterpillars were finally killed by an unusual snow-storm.

From this time to 1814 we have found no definite record of the caterpillar, but 1814 was again a year of serious loss in Louisiana, although it does not appear to have been marked upon the Atlantic coast. In this year the rather remarkable instance is seen of the almost total destruction of the crop as early as June.‖

1825 was again a year of general loss from the worms. The destruction was likened to that of 1804, and was universal throughout the whole cotton belt. Concerning this year we may quote from Dr. Phares:

> In 1825 the destruction was general in extent, embracing all the Cotton States; the late Mr. Affleck in one of his papers asserting that the destruction was "universal and complete." I must here be permitted to say that it was not "complete," as I most distinctly remember and know I saw fields in which many bolls were fully matured and gathered before the chenilles injured the plant, and considerable quantities of very superior cotton were made. This was the first year that I saw the chenilles, and circumstances so impressed me that my recollections of their appearance are more vivid than of any time since.

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*See Farmer's & Planter's Cyclopedia, London, 1843: Article, Cotton.

†*Southern Agriculturist*, 1828, p. 203 (Vol. I).

‡*Rural Carolinian*, August, 1870.

§Report upon Cotton Insects, 1879, Department of Agriculture, p. 387.

‖See *DeBow's Review*, 1847, p. 251 (P. Winfree), and Dr. Phares in *Rural Carolinian*, August, 1870.

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The insect was again destroyed by a storm, as we have seen happen less extensively several times since; the wind and rain beating them down, and the water sweeping them along and forming immense heaps in some places.

In 1826 the destruction is said by Dr. Capers to have been again universal, although other testimony to this fact is lacking. In limited localities the worms were noted in 1828, '29, '30, '31, '32, '33, '34, '35, and '36. Considerable damage was occasionally done, but it was by no means general again until 1838, the worms that year spreading over nearly the whole belt and doing especial damage in Florida and Southern Georgia.

In 1834 the worms appeared for the first time in Texas, and in 1840 in Arkansas. This last year was one of quite general injury to the crop, northern Florida suffering particularly. In 1841 Florida again suffered, as also in 1843. In 1844 the marked feature was the severe damage in central and southern Louisiana. In this State there was a shortage of nearly 50 per cent. of the crop on account of the damage done by the caterpillars. In Mississippi and Alabama some little damage was done the same year; but in Florida, Georgia, and South Carolina the loss was almost nominal.

In 1845 the damage was again considerable in Louisiana, and the other States suffered as well, the total loss from caterpillars being greater than in any other year since 1838.

1846, however, overshadowed, perhaps, all previous cotton-worm years. The caterpillars appeared in force much earlier than they had ever been seen before, and from Texas to South Carolina hardly a plantation escaped without loss. In South Carolina old inhabitants say that the ruin of the crop was complete. In Florida more than half the total crop was lost. In Alabama the loss was nearly as great. In Mississippi and Louisiana on a general average one-third of the crop was destroyed. Writing to the *American Agriculturist* September 9, 1846, from Washington, Miss., Mr. Thos. Affleck gives the following graphic account of the situation:

The Caterpillar, Cotton Worm, Cotton Moth (*Noctua xylina*), or chenille of the French West Indies, Guiana, &c., has utterly blighted the hopes of the cotton-planter for the present year, and produced most anxious fears for the future. I have heard from the greater part of the cotton-growing region—the news is all alike—the worm has destroyed the crop. I have no idea that any considerable portion of any State will escape. * * * The present year the crop is unusually backward, at least four weeks later than usual. We have but just commenced picking; usually beginning about the last week in July or the first week in August. At this moment every field within this region of country, say south of Vicksburg, is stripped of everything but the stems, the larger branches, and a few of the first bolls, already too hard for the worms' power of mastication. The full-grown bolls not yet become hard are completely eaten out, a circumstance I have never heard of but once before, in 1825. The fields present a most melancholy appearance; looking from the bluff at Natchez across the river to those fine plantations back of Vidalia, nothing is to be seen but the brown withered skeleton of the plant.

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In Texas the coast counties were overrun, but the inland counties, with here and there a marked exception (Walker lost 50 per cent. of the crop), escaped without particular damage.

It was at the close of this year that the theory of periodical recurrence of the worms in destructive numbers every twenty-one years began to be mentioned in the newspapers. Some person, noticing that the years of great disaster, 1804, 1825, and 1846, were separated by periods of twenty-one years, formulated the theory that these periods were constant, and that in 1867 another similar invasion was to be expected. The confidence with which this idea was universally regarded warrants its mention here.

In 1847 the months of June and July augured an exceedingly bad worm year, for the caterpillars appeared very early in considerable force and were widespread. The season, however, proved unfavorable to their great increase, since it was remarkable for periods of great heat and drought, interrupted by an occasional severe storm, and comparatively little damage was done by the caterpillars, although the crop suffered from the other causes mentioned.

From this period to 1866 there was, as far as we can ascertain, not a single general caterpillar year. The worms were every year to be found, and occasionally did some severe local damage. Thus in 1849, 1851, and 1852 the crops of northern Florida were injured quite seriously; 1852, 1854, and 1860 were quite marked in the canebrake region. In 1853, 1860, and 1864 the worms were more than usually injurious in Mississippi and Louisiana. In 1850 they made their first recorded appearance in Tennessee. 1864 and 1865 were marked by the appearance of the worms in North Carolina. The visitation in both of these years seems to have been severer than in any year since 1847, though it is difficult to compare them on account of the comparatively small amount of cotton grown during the war.

From 1866 up to the present date the worms have been widespread every year. It is a common thing to hear planters say, "The worm never used to be as destructive as this before the war"; and indeed the records seem to bear out the assertion. We may look for the reason, without doubt, in the general looseness and carelessness of the system of cultivation since, as compared with the clean and thorough methods before the war.

A large crop in 1866 was a necessity. Cotton had risen greatly in value, and as a consequence of this and of the liberation of the planters from martial occupation the acreage was largely increased over the preceding five years. Unfortunately, however, it proved a bad worm year. The losses may be averaged about as follows: Louisiana, Texas, and Alabama about 40 per cent.; Mississippi, 30 per cent.; Georgia, Florida, and South Carolina much less. The hopes and fears for the result of this crop and the disastrous effects of the advent of the worms are well told by Mrs. Harriet Beecher Stowe in an article entitled "Our

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Florida Plantation" (*Atlantic Monthly*, May 1879, p. 641). The worms were this year very destructive in southern Arkansas, and also did some damage in North Carolina.

There were not lacking those who, on the coming of 1867, prophesied a year of general devastation on account of the space—21 years—between this year and 1846; but, contrary to their expectations, 1867 was but little worse than 1866. Texas, it is true, suffered severely, but the other States were comparatively exempt. The districts along the Mississippi River in Louisiana, Arkansas, and Mississippi were damaged considerably, but the interior counties were injured but little. In Alabama, Georgia, and Florida the total losses were slight. Here and there the crop of a small district would be taken, but the average loss was low. In the latter part of the season the worms were numerous in South and North Carolina, but they injured the crop but little.

1868 proved to be one of the most disastrous years on record. The worms appeared in May in Texas, and the gravest fears were expressed from this early advent. On the whole, the loss in Texas and Louisiana did not equal that of the previous year. In Mississippi the loss was rather greater than in 1867. Alabama and Georgia suffered exceedingly; the loss in the latter State was entirely unprecedented. Through the central part of the State the average loss is reported at 50 per cent. In Alabama, with a few exceptions, the central and northernmost counties were damaged the most, the exceptions being Conecuh, Crenshaw, Barbour, and Montgomery. In South Carolina the crops were injured in some localities to the extent of a loss of 33 per cent. In North Carolina, though numerous, the worms were not destructive, clearing away the leaves just in time to assist in the ripening of the bolls.

One cannot help but notice, in studying these appearances of the worm from year to year, that they come in waves, gradually increasing, until at length, from one cause or another, they break and almost disappear. 1825, 1846, 1868, and, as we shall see, 1873, 1876, and 1881, are the culminating points of such waves or series of years during which the ravages of the worms have been gradually increasing, and in the year following each of these comes the breaking, and the next wave is begun. With a few unimportant exceptions, this rule is observed throughout the entire history of the Cotton Worm.

This result is natural, and arises from the tendency of the worms to increase in geometrical proportion and at a more rapid rate than their parasites. But whenever they have multiplied beyond the power of their food-plant to sustain them, or whenever meteorological conditions unfavorable to their increase obtain, the parasites get the upper hand and the break in the series occurs. This rise and fall has often been noticed by writers on injurious insects, but from the very nature of the case it is not regular, and cannot be depended upon.

1869 proved to be a year of drought, and there was a sudden decrease in the loss from the caterpillars. Here and there the crop of a county

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was taken, but the loss was by no means general. In Wayne County, North Carolina, strange to say, the worms came in August and injured the crop to a slight extent. South Carolina suffered no loss. In Georgia, the southern tier and the coast counties were damaged quite badly, but the remainder of the State escaped.

Of the northern counties in Florida, Bradford, Leon, and Putnam sustained quite severe losses, while Santa Rosa, Jackson, and Duval suffered none. In Alabama considerable damage was done to a few counties, as Wilcox, Macon, Dallas, and Greene. In Mississippi and Louisiana, the loss was insignificant. In Polk, Blanco, Matagorda and Goliad Counties, Texas, the cotton was badly eaten, but the remainder of the State was comparatively exempt.

The worms, instead of increasing in numbers in 1870, as should have been the case according to the rule just mentioned, were decidedly fewer and less destructive than in 1869, the same causes operating to produce this result, as 1870 proved to be a year of severe and long-continued drought. In North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi the worms were found, but almost no damage resulted. Isolated counties in Texas suffered, while in Louisiana by far the greatest damage of the year was done. Rapides, Avoyelles, East Feliciana, Tensas, and Jackson Parishes each sustained a loss of from 5 to 20 per cent.

In 1871 the increase again commenced, the principal damage, as in the previous year, being done in Louisiana. North and South Carolina sustained no loss, and Georgia suffered but slightly. In Florida the crop was so severely injured by heavy storms that the worms were hardly noticed. In Alabama and Mississippi there was a decided increase in the number of worms. In Louisiana the crop as a whole was very badly damaged, though in many parishes the loss was slight. The distribution of the points of heaviest injury was strange and difficult to explain. Great loss was sustained in Iberia, Saint Landry, Washington, Avoyelles, and Caddo; less in East and West Feliciana, Rapides, and Richland; while in Tangipahoa, Madison, Tensas, Red River, Claiborne, Ouachita, and Morehouse but few worms were to be found. In Texas the worms were widely distributed, but in only a few counties was even the top crop (representing 5 per cent. or a little more) taken. In Lafayette County, Arkansas, the late-appearing caterpillars damaged the crop to some extent.

In 1872 occurred another and greater increase in the damage done by the worms. In fact, the loss this year was so great that 1872 is entitled to be ranked as one of the years of general loss by the side of 1804, 1825, 1846, 1868, and 1873, although considerably inferior to the last-named and possibly to the early ones. The caterpillars appeared early in June in Florida, Louisiana, and Texas. In Texas the amount of damage was not great. In Louisiana it fully equaled that of the previous year. Tangipahoa, Marion, Concordia, Rapides, Saint Landry,

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Washington, Red River, and Jackson Parishes all sustained great loss. In Mississippi many of the central and southern counties were devastated, the more northern part of the State enjoying comparative immunity. We quote from the Monthly Report of the Department of Agriculture for September, 1872, as to the state of affairs in Alabama:

Our August returns from Alabama foreshadowed an extensive visitation of the cotton caterpillar, which, as our September reports show, was fully and painfully realized. In some places the boll-worm vied with the cotton-worm in its destructive influence. Reports of either or both of these pests come from Macon, Pike, Marengo, Conecuh, Perry, Montgomery, Crenshaw, Russell, Fisk, Calhoun, Chambers, Butler, Autauga, Dallas, Wilcox, and Tuscaloosa Counties. In Crenshaw the fields were denuded of foliage. In Calhoun the crop prospect was reduced 25 per cent. in five days. In Autauga the roads, woods, and wells were full of army and boll worms. In Wilcox the caterpillars, after stripping the cotton-plant of its leaves, attacked the bolls, eating the smaller ones and killing the larger ones by gnawing around them. In Perry the crop was cut down to half an average after August 20. In Conecuh the destruction was almost complete, as it also was in Russell. All through the cane-brake region the loss was very severe. Butler, Clark, Wilcox, Dallas, Perry, and Tuscaloosa report a loss of one-half; Pike, Bibb, Hale, Calhoun, and Limestone a loss of one-fourth or over.

In Florida also the loss was very great; Suwannee, Leon, Taylor, Columbia, Orange, Jackson, and Jefferson Counties all lost from 50 to 75 per cent. of their crops, while Clay County lost 33 per cent. Nearly every cotton-growing county in Georgia and South Carolina was visited sooner or later, but the losses were not great compared with those of Florida and Alabama. The worms were also remarkably widespread and abundant in North Carolina, although not particularly injurious. They also appeared in southern Arkansas.

In the whole history of the Cotton Worm in the United States, from 1793 down to the present time, it is doubtful whether 1873 was ever equalled (certainly never exceeded) in the loss occasioned by worms. Throughout the whole extent of the cotton belt hardly a plantation escaped, and in many cases the crop was a total loss. In many localities the caterpillar made its appearance for the first time, and has not since been reported. There must have been a very extensive hibernation of the moths, for as early as the latter part of May the worms had appeared in sufficient numbers to be reported from Florida, southern Georgia, Alabama, Mississippi, and Texas. The appearance of the destructive brood at the end of June was extensively reported, and the localities are of great interest as bearing upon the subject of centers of hibernation. They are as follows: Decatur County, Georgia; Liberty, Leon, Jackson, Gadsden, Suwannee, and Columbia Counties, Florida; Clarke, Wilcox, Dallas, Tuscaloosa, Barbour, and Saint Clair Counties, Alabama; Wilkinson, Marion, and Jasper Counties, Mississippi; Tangipahoa, West Feliciana, Concordia, Rapides, and Carroll Parishes, Louisiana; and Atascosa, Austin, and Galveston Counties, Texas.

It will be unnecessary to go through the list of States specifying

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which counties suffered the most. In Louisiana, Mississippi, Alabama, Georgia, and Florida the greatest damage was done. Texas did not suffer so much proportionately, although it experienced a great loss. In Arkansas, South and North Carolina more damage was done than had ever before been known; while in Tennessee and even in Virginia the worms were found in great numbers towards the close of the season.

The following extract from the Monthly Report of the Department of Agriculture for February, 1874, shows well the relative causes of injury to the crop of 1873, and the prominence which should be given to the caterpillar:

> The relative influence of each cause in damaging the crop of 1873, as indicated by our correspondents, may be stated in the following order in the different States:
>
> *North Carolina.*—Rains, frost, worms.
>
> *South Carolina.*—Rains, frost, worms.
>
> *Georgia.*—Worms, more than all other causes combined; rains, frost, drought, high winds.
>
> *Florida.*—Storms of rain, worms.
>
> *Alabama.*—Worms, rains, frost.
>
> *Mississippi.*—Worms, spring rains, drought, frost.
>
> *Louisiana.*—Worms, rains, high winds.
>
> *Texas.*—Worms, rains, drought, frost, bad gins and inexperienced ginners.
>
> *Arkansas.*—Rains, worms, drought, frost.
>
> *Tennessee.*—Drought, frost, rains, plant-lice, a cold and wet spring.
>
> In the Gulf States the greatest injury thus appears to have been wrought by worms, excepting only Florida, where the devastating storms in September and October, particularly that of September 19, proved more destructive than the caterpillar, which was abundant and sufficiently injurious.

The prevalence of rains will be noticed throughout the whole cotton belt in the above extract, and should be borne in mind as bearing upon the influence of rain and drought upon the abundance of the caterpillar; 1874, the succeeding year, will be seen to have been very dry and the worms were comparatively innoxious.

In 1874 the worms appeared rather early, but owing to the severe and long-continued drought did but little damage except in a few limited localities. The crop was poor, but this was entirely owing to the protracted dry spell. As one correspondent of the Department aptly expressed it, "the drought killed the cotton, and the worms too." Appearing in early June in noticeable numbers in Texas, Louisiana, and the other Gulf States, the increase in numbers was remarkably slow until it was too late for the crop to be greatly damaged. In some counties, notably Beaufort and Richland, South Carolina; Murray, Georgia; Lowndes and Wilkinson, Mississippi; and Burnet and Hardin, Texas, the leaves were well stripped, which served to render the plant more susceptible to the drought. Altogether 1874 may be considered a year of remarkable immunity.

The growing season of 1875 up to the month of August was also dry, while that month was marked by heavy storms. Both these causes

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operated to still further reduce the numbers of the worms; hence, 1875 is to be ranked as a year of even greater immunity than 1874. The worms were not noticed at all early in the season, and in the few localities where they did injure the crop, their late coming was all the more unexpected and seemingly disastrous. These localities were confined almost entirely to northern Florida, although some damage was reported from Austin and Polk Counties, Texas; Lowndes County, Alabama, and a few other counties. 1875 ranks as a good cotton year, the general average, according to the monthly statistical reports, slightly exceeding 100, the unit of comparison being normal growth and unimpaired vitality.

During the earlier part of the season of 1876 rains were very abundant over the larger part of the cotton-belt. Later, in September and October, the crop suffered from drought in Louisiana and parts of Texas, but in general the wet weather continued throughout the season. In consequence of this disposition of the weather in their favor, there was a most marked increase in the number of the caterpillars throughout the entire southern portion of the belt. In Georgia, Florida, Alabama, Mississippi, and Texas, the damage was considerable; but Louisiana escaped material injury. Owing, probably, to a small hibernation, the worms were not noticed particularly until late in July and August; but then the extremely favorable weather caused such a rapid development and great increase that they became destructive some time before the top crop could be saved. The State suffering the most was Alabama. The worms were more or less injurious in Marengo, Coffee, Clark, Bullock, Lauderdale, Crenshaw, Monroe, Lowndes, and Hale, and especially so in Dallas, Greene, Conecuh, and Perry. In Texas, Bastrop, Burnet, Fayette, Austin, Matagorda, and Waller were damaged, while, strange to say, both south and north of this group of counties the worms were reported as coming too late to do much damage. In this connection we may quote from an interesting letter from an Austin County correspondent, published in the Monthly Report of this Department for September:

> As predicted in my last, the Cotton Worm reached us last week, and devoured every particle that was eatable, leaves, blossoms, and small bolls. Never since my knowledge have these worms appeared in such a multitude. After having laid waste our fields, they thronged and blackened our lanes, roads, and highways; they penetrated lawns, yards, and even dwelling-houses, lying in the pathway, requiring the constant use of the broom to repel our loathsome guests. Hens, turkeys, and geese had a feast and grew fat. In this portion of the county the loss was not so severe as the gathering had already begun, and most of the bolls were fully grown; but the southern part, bordering upon an extensive prairie that reaches to the Gulf of Mexico, 200 miles distant, was attacked four weeks earlier, and the loss is a very severe one.

In Florida the damage was very unequal, the crops of Jackson, Jefferson, and Madison Counties suffering severely, while other adjoining counties were exempt.

In 1877 there was a falling off in the numbers of the caterpillars in

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the States which were injured the most the previous year, while in Louisiana, which almost escaped in 1876, the caterpillars this year were abundant and destructive. The September returns say: "The caterpillar is present in all of the Gulf States, and in South Carolina, but has done little damage as yet, except in Texas. In several of the parishes of Louisiana the loss is considerable from this cause."

The special feature of the year was the injury in Texas. Early in July the caterpillars were proving destructive in Hardin, Jasper, Brazoria, Atascosa, Victoria, and Uvalde. In August one-half of the counties sending in returns were infested more or less seriously. In Lavaca County the crop was almost completely destroyed, and Gonzales County reported a loss of 75 per cent. Before the close of the season Austin had lost 50 per cent., Hardin 75 per cent., Polk 75 per cent., and Waller, Colorado, Walker, and Fayette were all damaged to some extent. Among the Louisiana parishes injured we may mention Richland, Claiborne, East Feliciana, and Jackson. In Mississippi, the southern part of the State, including Wilkinson, Jefferson, and Covington Counties, was overrun, but the crop was not seriously damaged. Alabama and Georgia were comparatively unharmed, while in Florida the worms were numerous, but not particularly destructive. In the annual report of this Department for 1877 the loss from caterpillars for this year is estimated in round numbers at $15,000,000.

Concerning the occurrence of caterpillars in 1878, we are unable to get very full statistics, since the prevalence of yellow fever in parts of the South rendered correspondence difficult and drew the attention of the planters from their crops to their personal safety. The worms appeared early in Texas, and were reported soon after the 1st of June from Uvalde, Atascosa, Matagorda, Brazoria, Victoria, Lavaca, Fort Bend, Austin, Hardin, Polk, and Jasper Counties. In spite of this early appearance they seem to have spread but little, and in none of the counties mentioned did the loss exceed one-fifth of the crop. All through the cotton belt the season was a very fine one, and the crop raised largely exceeded that of 1877. In South Carolina, the worms were reported from Richland and Clarendon Counties late in the fall. In Georgia they were not noticed until late in August, and then only in the more southern portion of the State. Baker, Thomas, Dodge, Lee, and Early reported them in September, and later, Dooly, Laurens, and Worth. In Alabama and Louisiana the worms were, as in the preceding States, not reported until late, and their injuries were not severe. Coffee, Bullock, Covington, Dallas, Barbour, Macon, Baldwin, Crenshaw, Monroe, Conecuh, Dale, Wilcox, Lowndes, Autauga, Jefferson, Hale, Montgomery, Perry, Greene, Sumter, and Pickens Counties, Alabama; and Concordia, Caddo, Franklin, Lafayette, Madison, Bossier, and Bienville Parishes, Louisiana, all returned more or less damage. In two Arkansas Counties—Pope and Crawford—the crop was also damaged. In Florida nearly all of the counties belonging to

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the northern tier were infested, but none badly; the crop of Hillsborough County, farther south, was, however, considerably shortened.

In 1879 the worms were noticed and reported earlier than ever before, but this is due to the fact that active workers, attached to the Commission and to the Department, were on the lookout for them. They were reported in the canebrake region of Alabama by Mr. Trelease, and in the Colorado bottom, in Texas, by Mr. Schwarz, about the middle of May; 1879 was not, however, a bad worm year. Although some localities suffered considerable loss, the general loss was far from great. From the September report upon the condition of crops, issued by this Department, we learn the following: The caterpillars were present in great numbers on the 1st of September in Beaufort County, South Carolina; Baker, Dooly, Muscogee, Brooks, Lee, and Stewart Counties, Georgia; Putnam, Bradford, Sumter, and Marion Counties, Florida, and, in a lesser degree, in Madison, Leon, Suwannee, and Gadsden. In Alabama, Wilcox, Bullock, Coffee, and Perry suffered considerably, while Dale, Lowndes, Monroe, Barbour, and Conecuh were overrun with less resulting damage. Mississippi reported the caterpillars in Lauderdale, Rankin, Scott, Newton, Carroll, Lowndes, Oktibbeha, Copiah, Sharkey, Hindes, Leake, Holmes, and Jasper. Louisiana sent in not a single report of loss; and Texas only Austin, Trinity, Waller, and Harrison; Arkansas, Drew County. The November report increased this list by Thomas County, Georgia; Alachua, Wakulla, and Hamilton Counties, Florida; Clarke, Hale, and Lee Counties, Alabama; Amite, Newton, and Smith Counties, Mississippi; and Brazos and De Witt Counties, Texas; the two last reporting the crop as being almost entirely destroyed by worms. The year, as a whole, was not a favorable one for cotton; and the crop, as a whole, fell short of that of the previous year in spite of an increased acreage.

In 1880 there seemed to be no especially marked increase in the number of the worms over the previous year. The season was a favorable one for cotton throughout its whole extent in the Carolinas, Georgia, Florida, and Texas; although too wet after August in Alabama, Mississippi, and Louisiana, and dry in Arkansas and Tennessee. As early as June 4, the worms were reported as doing much damage in Bossier Parish, Louisiana, and in one or two Texas counties. In July they appeared in Decatur, Early, Quitman, Sumter, and Dooly Counties, Georgia; Gadsden and Madison, Florida; Bullock, Hale, Perry, Baldwin, Macon, Marengo, and Greene, Alabama; Panola, Covington, Clarke, Kemper, and Simpson, Mississippi; Pointe Coupée and Madison, Louisiana; Jackson, Falls, and Walker, Texas. The final reports for the season show that the damage in Georgia was considerable in Decatur, Lee, and Quitman; slight, or comparatively slight, in Screven, Troup, Early, Sumter, and Dooly; considerable in Lafayette, Florida, but less in Marion, Gadsden, and Madison; considerable again in Barbour, Elmore, Crenshaw, Bullock, Hale, and Macon Counties, Ala-

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bama, and less again in Marengo, Perry, and Greene; considerable in Panola and Noxubee, Mississippi, and less in Jefferson, Covington, Clarke, Kemper, and Simpson; considerable in Bienville, Caddo, Bossier, and Sabine Parishes, Louisiana, and comparatively small in Washington, Pointe Coupée, Madison, Ouachita, Saint Helena, Morehouse, and Calcasieu; considerable again in Comanche, Erath, Bastrop, Harris, Robertson, Wharton, Matagorda, Brazoria, Fort Bend, Austin, Limestone, Montgomery, Walker, and Brown Counties, Texas, and less so in Polk, Bexar, Karnes, De Witt, Jackson, Falls, Titus, Victoria, Harrison, Coryell, Montague, and Paine. In Arkansas, the crop of Hempstead County was damaged.

The following summary of the losses in 1881 is taken from the Annual Report of the Department of Agriculture for 1881-'82:

ALABAMA.—*Talladega:* Appeared late and only on luxuriant growth in some sections. *Limestone:* Shed more from want of proper cultivation and rain and drought. *Lawrence:* In low bottom-lands to some extent. *Conecuh:* All the top crop destroyed. *Barbour:* Partially in many fields rust preceded the caterpillars and destroyed what they would. *Perry:* Prairie early and sandy land later. *Chilton:* About three-fourths stripped of leaves early; after rain budded out but made nothing. *De Kalb:* Stripped in some sections. *Saint Clair:* Some fields were not touched while others were entirely stripped. *Cherokee:* Some fields stripped early, others not at all. *Russell:* On bottom-lands early. *Marengo:* Stripped entirely where no poison was used.

ARKANSAS.—*Hempstead:* Some spots none; others as high as 50 per cent. *Pulaski:* Earlier than ever before. *Woodruff:* Only the foliage and unmatured bolls. *Jackson:* By the Army Worm. *Montgomery:* Many fields stripped after the cotton had matured. *Pope:* Later than usual. *Howard:* Leaf Worm came early but did no damage. *Monroe:* Whole region stripped bare of foliage.

GEORGIA.—*Bibb:* On bottom and new land only. *Muscogee:* On lowlands early; uplands later. *Lowndes:* Second crop of foliage entirely stripped. *Hancock:* Entirely on low, wet lands. *Jones:* Stripped entirely on red lands; gray land suffered but little. *Dooly:* Only partially. *Morgan:* In consequence of the very late fall and frost. *Lincoln:* Few fields. *Liberty:* Partially. *Early:* Some localities early. *Oconee:* Picking of the best cotton was done before the worms came.

FLORIDA.—*Columbus:* Many fields stripped. *Madison:* Only in portions of the county. *Sumter:* Was stripped entirely.

TENNESSEE.—*Bedford:* Boll-worms are unknown here, though caterpillars stripped the leaves. *Lincoln:* Stripped of leaves. *Dickson:* Very little damage done in this county. *White:* Boll-worms do the most damage.

SOUTH CAROLINA.—*Oconee:* Only partially in limited localities. *Greenville:* Crop made before worms came. *Newberry:* In some localities, but so late in season as not to injure yield; rather benefit it by exposing the unopened bolls to sun. *Abbeville:* Where it appeared did not more than eat the leaves on the plant. *Barnesville:* Stripped clean of leaves and young bolls, which came too late to make anything.

NORTH CAROLINA.—Came too late to do any damage. *Lenoir:* Did not appear only in a few places. *Columbus:* Only appeared in a few places and too late to do any damage. *Cabarrus:* Did not appear till after crop was picked; they then stripped the plant. *Wilson:* A few appeared just before frost, but did no damage. *Cumberland:* Few fields had the leaves eaten off, but too late to do any damage. *Pitt:* Few places they appeared, but too late to do any damage. *Cleveland:* Very little.

LOUISIANA.—*Union:* A few places had then reported, but no damage done. *Jackson:* Stripped, but after maturity. *Lincoln:* In some places, but not until after it was picked. *Franklin:* Not until picking was over, then only partially. *East Carroll:* Stripped, except very high land or shaded.

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MISSISSIPPI.—*Union:* In some localities, but after cotton matured. *Tate:* Second growth eaten by them (leaves) bolls not hurt. *Chickasaw:* Army Worm destroyed top crop. *Alcorn:* In a few localities, but after the crop had mostly opened. *Prentiss:* Did not appear until about frost, and did no harm. *Rankin:* Very little, and after bolls were matured. *Jefferson:* Destroyed all top crop. *Clay:* Bottom crop at maturing. *Issaquena:* Only partially, and that late. *Clarke:* Owing to the early drought the leaves became so hard and dry that they made very slow progress.

TEXAS.—*Gonzales:* In some places early; others late. *Bee:* Damage at first of season by Grass-worm. *Colorado:* In some sections where not poisoned. *Denton:* Partially by the Web-worm. *Lee:* Where poison was not used the plant was generally stripped. *Houston:* In very few sections, and very late. *Wise:* Came, but too late to do harm. *Brazos:* Very late; too late to injure. *Live Oak:* In some localities. *Wood:* Too late to damage. *Lampasas:* Came too late to damage. *Milam:* Second crop damaged in some localities. *Van Zandt:* Caterpillars came early and made clean sweep. *Grimes:* Only top crop injured, which seldom amounts to anything. *Palo Pinto:* Stripped but very little. *Leon:* In some places, but too late to do damage. *Fannin:* Some fields were stripped, but not until it was all opened.

HISTORY OF REMEDIES.

From the early days when the Creoles of Louisiana fought the chenille which was destroying their cotton, with "holy water," down to the present time, when the improved sprinklers, with their extended arms and many jets of poisoned spray, are drawn through the fields, destroying the worms upon eight to twelve rows of cotton at once, it is plain that immense improvement has been made. Let us glance at the steps by which this was brought about.

Naturally the first remedy which the planter would try would be to destroy the worms by hand, and this really was, so far as we can find, the first method used. The next remedy was suggested by the avidity with which poultry devoured the worms. Dr. Chisholm says concerning his observations in Guiana in 1801–'02: "A prudent, economical planter will increase the brood of every species of domestic poultry, particularly turkeys; for this has a tendency to diminish the brood of the chenille in a very great degree, while profit arises from the augmentation of useful stock. Turkeys are observed to have a remarkable appetite for the larvæ of the Cotton Moth and devour prodigious quantities of them." With this remedy, however, Dr. Chisholm's practical ideas seem to cease, for he goes on to describe how the worms may be killed by burning sulphur on a chafing-dish, the plant being covered meanwhile by a canvas hood! By the use of this remedy (as Mr. Wailes many years afterwards very justly remarked) a hand might, with exceptional diligence, go over an acre in *fifteen or twenty days!*

For many years hand-picking and the keeping of large poultry yards were the only remedies practised; yet excellent success was attained where thorough and energetic planters tried to save their crops by these means, as is evinced in the following quotation from Seabrook (1843):

The caterpillar appeared in several parts of the field of John Townsend, of Saint John's, Colleton, early in August last. The plants were luxuriant in growth and tender in weed and leaf, and the weather, being warm and rather moist, was altogether

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propitious to the spread and multiplying of the worms. By the adoption of prompt and vigorous measures, some of which are new, and a rigid perseverance in their execution, his crop escaped unscathed, while many of his fellow-laborers who lacked faith in any remedy suffered greatly. In the attainment of his purpose the means resorted to by Mr. Townsend were the following:

1. His people searched for and killed both the worm and the chrysalis of the first brood.

2. On the appearance of the second brood he scattered corn over the field to invite the notice of the birds, and while they depredated on the worms on the top of the stalks and their upper limbs, the turkeys destroyed the enemy on the lower branches.

3. When in the aurelia (chrysalis) state the negroes crushed them between their fingers.

4. Some patches of cotton where the caterpillars were very thick and the birds and turkeys could not get access to them were destroyed.

5. The tops of the plants and the ends of all the tender and luxuriant branches, where the eggs of the butterfly are usually deposited, were cut off.

By these means, resolutely pursued, although at one time the prospect of checking the depredators was most cheerless, not the slightest injury to the field was sustained. The experiment cost Mr. Townsend 2½ acres of cotton, about 15 bushels of corn, and the work of all his people for about five days.

It will be noticed that among the remedies used by Mr. Townsend was that of topping the cotton, under the supposition that most of the eggs are laid upon the upper and tenderer leaves. This was one of the early remedies, but has often been urged since, and has its disciples to the present day. As we shall show in discussing preventive measures, it may be employed to advantage in some cases late in the season, but at the most critical period of the year the eggs are mostly on the lower part of the plant.

About 1840 Mr. Wailes first publicly recommended the carrying of lighted torches through the fields at night to attract and kill the moths. Soon after, large fires began to be built in different parts of the plantations for the same purpose, and, later, these fires were built upon elevated platforms floored with earth. It is stated, however, by Dr. J. C. Neal, that Col. F. D. McDowell, an old Florida planter, had begun the use of fires to destroy the moths as early as 1805. First and last this remedy has been extensively tried; but the general verdict seems to be against its utility. It is held that such fires attract to a plantation many more moths than they kill. One author has even gone so far as to dispute that any moths are destroyed in this way, stating that repeated observation has shown to him that the rush of hot air carries them up and away before they can reach the flame.

Prior to 1855 were published a number of articles recommending the flying of white flags in different parts of the fields, and stating that the moths would oviposit upon them. Each published recommendation, however, was from hearsay, and no one of the writers was able to say that he had ever seen a single egg upon such a flag. Where the idea started we are unable to say.

Clean cultivation, forcing the cotton, and rotation of crops had all been urged by writers before this, and followed by many planters, no doubt with much advantage.

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Many fanciful remedies had also been suggested, such as soaking the cotton seed in a poisonous mixture on the supposition that the egg of the worm was contained in the seed; fall-plowing, on the supposition that the pupa hibernates under ground; burning the cotton stalks, as they were supposed to contain the eggs; burning the nests of the web-worms on trees, which were thought to harbor the Cotton Worms during the winter, and many others equally fallacious.

The use of plates with an adhesive sweet of some sort, to attract and capture the moths, had been tried for some years prior to 1855, but we believe that Glover was the first to publicly suggest the addition of poison to the mixture. So also Glover, in his 1855 report, was the first to describe a trap lantern for catching and destroying the moths.

In 1860 the idea of poisoned sweets was elaborated by Mr. J. M. Heard into a patent moth trap, which has been quite extensively used throughout the South, and which is spoken of in the chapter on remedies.

After the close of the war the planters seem to have awakened from the partial apathy which they had before shown on the subject of remedies. In Louisiana a sweep plow was invented which brushed the worms from the plants and buried them under ground. Numerous styles of trap-lanterns were invented; solutions of cresylic soap, carbolic acid, and other less efficacious compounds, such as decoctions of quassia and infusions of China berries, were tried, but with only partial success in the case of the former, and none in the case of the latter.

It was not until 1871 that arsenic began to be used in solution. In January of that year Thos. W. Mitchell, of Richmond, Tex., obtained a patent for its use against the Cotton Worm.

In June of 1872, at the organization of the American Agricultural Congress at Saint Louis, it was our privilege to deliver before the Convention a lecture on Economic Entomology. There were many Southern delegates present, and in the discussion which followed the lecture we suggested, in answer to inquiries from General Wm. H. Jackson, of Nashville, Tenn., and Dr. J. O. Wharton, of Terry, Miss., that the Paris green mixture, which was proving so successful against the Colorado Potato-beetle at the North, might be equally efficient against the Cotton Worm in the South.

In May, 1873, having in the meantime experimented with Paris green upon various Lepidopterous larvæ allied to the Cotton Worm, we read an essay before the second meeting of the Congress at Indianapolis, in which we strongly and unhesitatingly recommended the use of the green for this particular insect. An abstract of the essay was published in the Saint Louis *Journal of Agriculture*, and this was very generally copied in the agricultural press, especially of the South. The extensive use of the green for this purpose dates in reality from this period, though there is evidence that it was used in Texas and in Alabama, in 1872, whether as an outgrowth of our remarks at Saint Louis in June,

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or from the logical reasoning of some energetic planter or planters, it is impossible to say.

Recently, however, Mr. J. P. Stelle, agricultural editor of the Mobile *Register*, has put forth his own claim to having been the first to publicly recommend the use of this poison for the Cotton Worm. This claim he bases upon an article which appeared in the *Register* in August, 1872.

This article appeared as an editorial in the body of the paper and not in Mr. Stelle's agricultural department, a fact which in itself would argue that he was not its author. Moreover, the article does not specifically recommend the use of the green, but simply announces the fact that it is being tried. We quote the paragraph in which it is found:

We have but little to offer in the way of remedies with which to combat this pest of the planter. Hand-picking the plants is sure but hardly practicable in all cases. Fires built about the field at night would be likely to do some good in the way of destroying the moth, as it has a natural disposition to fly into them. We know of several persons who are now experimenting with dry Paris green sprinkled upon the plants after having been mixed with 15 or 20 parts dry ashes or slacked lime, and we hope to hear a good report from them.

It is, moreover, an extremely significant fact, and indicative of the authorship of this paragraph, that in Mr. Stelle's subsequent writings (see, for instance, "The Cotton Caterpillar and How to Combat it Successfully," *Rural Carolinian*, July, 1874) he gives the entire credit of the recommendation to our essay before the Indianapolis meeting in May, 1873; and it is only recently that he has laid any claim whatever to an earlier announcement.[22]

In the fall of 1873 the following circular, doubtless prompted by our Indianapolis address, was issued and distributed throughout the South by the Commissioner of Agriculture:

PROTECTION AGAINST COTTON INSECTS.

To Correspondents:

The annual losses of cotton from ravages of cotton insects amount possibly to half a million bales in years of insect prevalence. One-fourth of a million bales would be deemed a light infliction, and yet, at $100 per bale, such a loss would be equivalent to $25,000,000. The methods to be employed for lessening their ravages have been heretofore canvassed by the Entomologist of this Department. The remedy can only be applied by the planters themselves, and their own experience can best render practicable and efficient the means employed.

Numerous correspondents have of late been experimenting with a mixture of Paris green and flour or plaster, dusted on the plants when wet with dew—a remedy which has proved very efficient against the Colorado potato-beetle and other insects. Some report this remedy effectual against the cotton-caterpillar, while others declare it of no value whatever; others, still, hesitate to try it for fear of poisoning. It is of the utmost importance that the facts in the experience of planters the present season should be carefully reported, showing the quality and proportions of material used, the method and frequency of its application, and the observed results, that a thorough test may be made of its value or worthlessness. The answer of the following questions is therefore requested:

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I. What is the result of your experience or observations as to the efficacy of Paris green, or other arsenical compounds mixed with flour or plaster, for the destruction of the cotton-caterpillar?

II. In what proportions, and in what mode, time, and frequency of application have experiments been made?

III. Have any injurious effects of the poison been observed, either upon the plants or the soil, or in human poisoning in its application, or in the destruction of beneficial insects, as bees, &c.?

IV. Have you used any other remedies, or means of extirpation, such as fires or torches in the fields to destroy the perfect moths on their first appearance, and with what success?

Yours, respectfully,

FRED'K WATTS,
Commissioner.

The answers to this circular, published in the Department report for 1873, showed that the green was tried during the season in seven States and seventy counties, and that its success had been almost uniform.

The same year several patents were taken out for poisonous mixtures to be used in destroying the Cotton Worm, and some of them reached a great sale for a few years—notably Preston & Robeira's "Texas Cotton Worm Destroyer," and Johnson's "Dead Shot." But it has become generally understood that the same ingredients can be used in slightly differing proportions without infringing upon the patents, so that at the present day the patents are generally disregarded.

In the Monthly Report of the Department for November and December, 1872, Mr. E. H. Derby, of Boston, remarking upon the fact that the worm would not eat jute, suggested that a belt of that plant around a cotton-field might keep the worm away. A year later, in the Monthly Report for November and December, 1873, Mr. E. La Franc, president of the Southern Ramie Planting Association, detailed experiments with three fields, which seemed to prove the practicability of the use of jute as a preventive. Subsequent experiments, however, have failed, and it is probable that from this article of Mr. La Franc's have spread the numerous reports of the efficacy of jute, which are to be found in the back files of many Southern papers.

Since 1873 most of the advance in remedies has been in the way of invention or improvement of machinery for the distribution of the poisonous mixture upon the plants. This machinery will be fully discussed in the chapter on remedies.

The cheap arsenical poison known as London Purple was first experimented upon as a Cotton Worm remedy by us during the season of 1878, and the favorable results which followed its use induced extensive experiments the next year.

It is hardly necessary to add that it has grown into great favor wherever it has been obtained pure and has been judiciously used.

The only remaining remedy of importance—Pyrethrum—was first publicly recommended by the writer for this purpose in first edition of this work, our first experiments with it upon the worms having been made during the summer of 1878.

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CHAPTER IV.

THE COTTON WORM IN OTHER COUNTRIES.

Aletia xylina, although widely spread in the Western Hemisphere, has not yet been found, as far as we are aware, in the Eastern. The cotton crop in the Eastern countries, in Egypt, Greece, India, Australia, has its insect enemies: in Egypt, a Noctuid larva; in Greece, various species of Cut-worms; in India, the Tineid Boll-worm, *Depressaria gossypiella;* in Australia, a red bug allied to the *Dysdercus suturellus* of the West Indies; but *Aletia xylina* has as yet been found only in North and South America and the intervening islands.

Up to the present time the northernmost point at which Aletia has been collected seems to be Quebec; and as to its southern limit, there seems little doubt but that it is found in São Paulo, one of the southern provinces of Brazil. Its western limit is the Pacific, although we have no information as to its occurrence in California, even in the cotton fields in the southern part of the State. It is found, however, upon the coast further south at Mazatlan and Manzanillo, Mexico, as shown in the following extracts from correspondence which we have had with the United States consuls at these ports, Aletia being identified in most cases from specimens received:

CONSULATE OF THE UNITED STATES,
Masatlan, December 3, 1879.

* * * The Cotton Worm, or as known here by the name of the Army Worm, the Bud Worm, and the Boll Worm, are the worst insect enemies. The regular Cotton or Army Worm attacks the cotton plant every year, but about once in four years is very destructive. It appears to be deposited by a fly on the underside of the leaf, which rolls up, and in a few days the worm, of about 2 inches, appears. During the winter months it disappears. Cotton was first introduced into this State, in 1863, by an American, Mr. Francis Nolan; it was produced from seed brought from the State of Guerrero. It does not grow wild in this State. The first years but little trouble was experienced from the Cotton Worm; but each year they have given more trouble, especially if cotton is planted again on the same ground. The prevailing direction of the wind during the months from March to July is from the east in the morning, and from the southwest in the afternoon.—[E. G. Kelton, United States Consul.

MANZANILLO, MEX., *December* 26, 1879.

The larger worm or caterpillar (*Anomis xylina*) has made it appearance on this coast three times during the last twenty years, in 1866, in 1873, and again in 1878. It is a dark green looking worm, with white and black lines, and destroys the cotton plant by devouring the leaves. It is as yet impossible for me to find out the origin or even habits of this worm. I have investigated the supposed causes of its appearance, but without success; the farmers here have not the slightest idea about it. An apparent

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coincidence between the appearance of this plague and overflooding of rivers in the cotton regions should be mentioned.

1865, September, high floods, complete inundation of cotton lands. February, 1866, appearance of the caterpillar in small numbers, not causing much damage.

1872, September, floods, partial inundation of cotton lands, high lands and ridges in the valleys not flooded. February, 1873, appearance of the plague, and total destruction of cotton plantations.

1878, September, high floods, complete inundation of cotton-growing valleys. 1879, February, partial plague, small damage done by the caterpillar.

I am of the opinion that the worm has not been imported into Mexico, but originates in the cotton valleys in such seasons, when the peculiar condition of the soil and climate combine to favor the development of the larva.

The cotton lands in this vicinity are bounded on the W. by the Pacific Ocean, on the E. by high mountains, la Sierra Madre, on the N. and S. by dense woods and tracts of uncultivated lands. These circumstances present a great many obstacles to the flight of the Cotton Moth. The nearest cotton plantations, as well to northward as to southward, are at a distance from Manzanillo of at least 100 miles.

Cotton has been grown in the State of Colima for the last fifty years. It does not grow wild, but if abandoned, some plants grow up to good sized trees, bearing fruit regularly every year.

The directions of prevailing winds on this coast are the following, viz:

January, S. and W.; February, W. and N. W.; March, W. and N. W.; April, N. W.; May, N. W.; June, S. and N. W.; July, S. and W.; August, S. and W.; September, S. and W.; October, S. and W.; November, S. and W.; December, S. and W.

The north and northwest winds blow generally during the day. At night these winds change to the north and northeast.

I give the prevailing winds for the whole year, as our planting and picking seasons here are different from those in the United States.—[Augustus Morrill, United States Consul.

On the Gulf coast of Mexico Aletia is also found. The following account of its work in the consular district of Vera Cruz is from the *American Entomologist*, Vol. III, p. 179 (July, 1880):

INTERESTING COTTON WORM NOTES FROM VERA CRUZ, MEXICO.—In this consular district about 8,000,000 lbs. are produced. The peculiarities of culture are striking. The ground is prepared by removing rubbish, and then the seed is planted by inserting a sharp stick in the ground at convenient intervals; into the holes thus made the seed is deposited and covered by the foot. No plows are used in this preparation for the seed, nor are they often used in the subsequent stages of cultivation. They pull out the larger weeds or use the hoe, confining their labor to little more than such. It is clear from that kind of culture that the cotton plant must be forced into much bad company, and be assaulted with destructive enemies. After extensive inquiries I find no one scientifically informed on the full habits of these enemies.

* * * * * * *

It is a hotly disputed point as to what becomes of the worm during the "six or eight years" when it does not appear, and no one in my circuit of acquaintance gives me anything better than a superstition for a solution of the problem. Our climate, never giving us frost, scarcely affects the constant germinal qualities of plants or the enemies thereof, and it has been asserted to me that at one place or another the Cotton Worm can always be found. However, the difficulty I have experienced in obtaining the specimens sent, induce me to doubt the correctness of that assertion.

* * * * * * *

The worm has been here as long as cotton has been cultivated by the Mexicans.

We have historical accounts that cotton was grown and utilized since the twelfth century, but have no data that it was or was not naturally indigenous. But if said

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history be reliable it is fair to presume that it was indigenous, because there is no knowledge of commercial relations with foreign countries at that period.

* * * * * * * *

The winds here are easterly and southeasterly.—S. T. Trowbridge, U. S. Consul, Vera Cruz, Mexico, March 3, 1880.

I send you a bottle containing various kinds of worms that destroy the cotton and plant. They are all I have been able to procure. This is now the part of the year in which the worms usually appear, and they have been gathered near San Andres Tuxtla, on the southern coast from here.

* * * * * * *

On the coast they are called *palomas* (moth) or *salomilla* (chrysalis or aurelia). Said paloma is ash-color, and is nocturnal in its habits. The moth produces a multitude of microscopic eggs on the plant, which eggs create the worm, also microscopic, and which commences immediately to devour the plant, and so continues until it gets to the state of enrolment, in order to pass through the last metamorphosis. I have not been able to obtain sufficient data to say whether they were imported into this country, but I am assured that they do not make their appearance every year at the same place, or, better said, they only come one or two years in succession, then disappear for six or eight years. They are not to be found in all the country at one time. Their reproduction is usually ascribed to our southern coast.

* * * * * * *

I understand their invasion can be victoriously combated by sprinkling dry chloride of lime over the ground and plants, or an aqueous solution of the same, and I have recommended this remedy to those living on the coast for a trial.—R. de Zayas Enriques, Vera Cruz, March 2, 1880.

[The worms sent by Señor Enriquez are the genuine Aletia of all sizes, but mostly full-grown. The facts communicated in the above reports are most interesting, not only on account of the remote period to which the growth of cotton may be traced on this continent, but also because of the general observations as to the reoccurrence of the insect in injurious numbers at irregular periods only. In other words, the insect presents the same phenomena in Mexico as in this country, and the same facts upon which the theory of annual immigration to the United States have been largely based will hold equally true of a country essentially below the frost line. This all goes to prove the correctness of our conclusions that the absence of Aletia during certain years is apparent only, and that its undue multiplication during other years is paralleled by similar phenomena in respect of many other insects, and notably of the Northern Army Worm, the apparently sudden appearance and disappearance of which over vast regions is even more marked than in the case of Aletia. Yet, as we have shown in the case of both these insects, they may always be found in limited numbers even when their presence is not suspected.]

The following notes on the appearance of the worms in Yucatan, we extract from our correspondence:

UNITED STATES CONSULATE AT MERIDA,
November 22, 1879.

The culture of cotton is very slight here. It is cultivated only in the southern part of this city, and in very small quantity; it grows to the height of 12 feet. No other insect enemies are known but the worm, and this worm is exactly as described; that is, a green worm with white lines and black dots. This worm is always on the cotton leaf, and there is no doubt that eating the leaf it kills the plant. It does not touch the boll, as it remains always on the leaf. If possible I will send specimens.

Cotton has been growing here for more than sixteen years and grows wild, but it is inferior to the cultivated plant. The prevailing direction of winds during March, April, June, and July is generally southeast.—[M. Ceballos, U. S. Vice-Consul.

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Passing over to the West Indies, we find that the caterpillar was destructive to cotton in the Bahamas from the earliest cultivation of the plant. In 1788 we are told by various narrators that 280 tons of cotton were destroyed. In 1794 two-thirds of the crop on Acklin's Island was lost. From this time up to the emancipation of the slaves, in 1834, the worms were injurious every year, but at this time the cultivation of the crop ceased until the outbreak of the civil war in the United States, when it was again begun, only to cease at the close of the struggle. According to the inhabitants, the Cotton Worm has not been seen since a great hurricane which visited the islands in 1866, and Mr. Schwarz, in the spring of 1879, was unable to find a trace of it in any stage.

In Cuba the cultivation of cotton ceased some fifty years ago, and Mr. J. P. Guarché, United States consul at Matanzas, wrote the Department, in 1855, giving as the reason the superior profits of sugar cane and tobacco, and the fact that "the soil generates a worm which attacks the cotton plant and destroys the greater part of the crop almost every year. This worm is said to infest the plantations of our Southern States, but its ravages there are represented to be trifling in comparison with what they are here."

In Santo Domingo, Porto Rico, Trinidad, Barbuda, and Guadaloupe, the Cotton Worm has probably always been present, but we have no absolute information beyond the fact that in the British Museum Catalogue of Lepidoptera, Part XIII, p. 989, four specimens of *Anomis grandipuncta* (synonym of *Aletia xylina*) are entered from Santo Domingo.

In Martinique it exists without much doubt, as appears from the following:

UNITED STATES CONSULATE,
Martinique, W. I., December 11, 1879.

Cotton is not cultivated to any extent in Martinique. There is not a cotton plantation upon the island; there are only a few traces here and there, and these grow wild upon the southern part of the island. The worst insect enemy is a green-looking worm with white points on either side. I am told that this worm has been here since the first cultivation of cotton upon the island. The prevailing direction of the wind during the months of March, April, June, and July is east-northeast.—[W. H. Garfield, United States Consul.

Cotton was formerly one of the staple crops of this island, and Mr. Grote in his report to us states that he was informed by the Hon. Robert Toombs that in 1801–'02 there was an emigration of French cotton planters from Martinique to Georgia on account of the ravages of the Cotton Worm.

In the northern countries of South America Aletia is abundant without doubt. The British Museum (*loc. cit.*) possesses specimens from Venezuela, and the following note from Maracaibo refers to this species:

UNITED STATES COMMERCIAL AGENCY,
Maracaibo, Venezuela, February 18, 1880.

* * * The worst enemy of the cotton plant is the caterpillar. There are two distinct kinds. One is green and rather small, and the other kind has a green belly

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and yellowish back with brown stripes. * * * The caterpillars generally appear in the spring-time; that is to say, in February and March, and at times in such quantities that they succeed in destroying whole plantations of cotton. If, however, the rainy seasons continue a short time beyond their usual period, they are almost all destroyed by the rains.

These caterpillars have been known ever since the first time that cotton was raised here, and, so far as I can gather from information received, are indigenous to the country and in no way imported from elsewhere. * * * The winds that prevail in that part of the country are north-northeast and south-southeast.—[E. H. Plumacher, Commercial Agent.

The smaller caterpillar referred to is Aletia, and the larger one a large sphingid larva.

In British Guiana the Cotton Worm was in former years very abundant and destructive. Dr. Chisholm* has given a long account of its method of work and the remedies, which is quoted freely in the Report of the Department of Agriculture on Cotton Insects, 1879 (pp. 72, 73). Dr. Ure (1835) also states that the *Chenille* is the most destructive enemy to the cotton crop in British Guiana.

In Dutch Guiana the Cotton Worm has always been destructive, and Mr. F. W. Cragin, United States Consul at Paramaribo, writing to the Department of Agriculture, in 1856, identifies the destructive insect with *Noctua xylina* Say.

In Brazil, *A. xylina* has been found at various points. Our most trustworthy information is contained in the report of Mr. John C. Branner (Appendix V). Messrs. Branner and Koebele, as shown in this report, reared this species from the larva at Bahia and at Bonito (Province of Pernambuco). In the British Museum list previously cited, *A. grandipuncta* is given from Santarem (Province of Para). The following concerning the Cotton Worms at Bahia is from the *American Entomologist*, Vol. III, pp. 128, 129 (May, 1880).

COTTON CULTURE AND THE INSECTS AFFECTING THE PLANT AT BAHIA, BRAZIL.

Cotton is not grown at present to any considerable extent in this province, and has ceased to be an article of exportation. The cultivation is simple in the extreme, requiring little care or attention, but owing to the distance from this part of the cotton-producing districts, the cultivation has long since ceased to be remunerative.

The insect enemies of the cotton-plant which particularly attack it, consist of two species of moths, which in the form of worms or caterpillars prey upon its leaves and stalk as also the cotton pod itself. It is also attacked by a peculiar species of bug, a specimen of which is forwarded, and by the grasshoppers, which commit great ravages on the foliage and the tender stalks.

The "Cotton Worm" as described by Professor Riley is somewhat different from the worm found in this province, differing in color and other respects, but it is no doubt of very similar character.

The ravage committed by them is greater in the dry or summer months, say September, October, November, and December.

This Cotton Worm is believed to have been always in the country, and not imported.

Cotton has been grown in this part of Brazil for as long a time as any other production, and it is also found growing wild.

*Brewster's Edinburgh Encyclopedia: Article Cotton.

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The prevailing direction of the wind during the months of March, April, June, and July is easterly, varying from N. E. to S. E.—Richard A. Edes, U. S. Consul, Bahia, Brazil.

One of the caterpillars referred to by Mr. Edes is the larva of a species very near and perhaps identical with *Aletia argillacea* Hübn., as proven both by specimens received from him and others collected and bred by Messrs. Branner and Koebele, while the other is undoubtedly *Aletia xylina*.

From Pernambuco we have had the following excellent account:

UNITED STATES CONSULATE,
Pernambuco, March 20, 1880.

* * * The foes most fatal to the cotton plant are the different kinds of caterpillars, which in some years increase to a frightful extent, destroying entirely the crop and the pasturage; the absence of rain, and "the blight." * * *

The Cotton Worm or caterpillar, *Anomis xylina*, particularly described in your letter, attacks the plant in these provinces. It appears simultaneously with the other varieties at the beginning of the rainy season, and never alone. It comes and disappears with the rain.

So far as can be ascertained from observation, the *Anomis xylina* is believed to be a native of the country. During some entire years it is extremely rare to see a caterpillar, whether there be sun or rain, wet or dry weather. Some varieties, however, seem consequent upon the action of the sun, and others upon the action of the rain, appearing and disappearing as if by enchantment.—Andrew Cone, U. S. Consul.

In the more southern provinces of Brazil there is also a destructive Cotton Worm, but its identity with Aletia has not been established. The following paragraph from the report which Prof. J. E. Willet made to us in 1878 refers to the work of this worm:

Dr. E. L. McIntyre, of Thomasville, Ga., writes: "I settled in the province of Sao Paulo, Brazil, in the year 1866, and remained there eight years and a half. The cultivation of cotton was of recent date then, and they were planting their fourth crop when I arrived. Prior to the year 1863 there had been some cotton planted in the country, perhaps of an indigenous variety, but no one had ever observed a Cotton Worm, and I believe they had never existed there. In 1862 the price of cotton offering great inducements to Brazilian farmers, they sought to procure seeds, but none could be had, and I am informed the seed then being used was brought from New Orleans. The first year no caterpillars were seen, but after the second they commenced to eat the leaves, and had increased to such an extent that when I moved from there the cultivation of cotton was nearly abandoned."

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CHAPTER V.

ON THE ANATOMY OF ALETIA.

By Charles Sedgwick Minot and Edward Burgess.

[Plates VI–XI.]

The following chapter was prepared at the request of Professor Riley, to whose kindness we are indebted for the material upon which our observations have been made. Several untoward circumstances have contributed to interfere with the progress of the investigation. The work was begun by Dr. Minot, who was subsequently joined by Mr. Burgess, in the hope that our joint labors would prove more efficient. Nevertheless we find it necessary to leave various points undecided. This incompleteness is partly due to the unavoidable imperfection of preserved specimens,* and partly to the scanty light yet thrown on insect anatomy and physiology.

ANATOMY OF THE LARVA.

The external anatomy of the larva need not be again described in this chapter. There are only a few points to be noted in regard to the legs, the previous descriptions of which are somewhat incomplete. The true legs, Plate VI, Fig. 4, are conical, three-jointed, and provided with a terminal hook, Fig. 6, which is curved toward the median line of the body, and has at its base a thick swelling, usually described as a fleshy pad; the adjective fleshy is hardly appropriate, as the pad is covered by a well-developed, hard crust. There are two hairs on the first joint, the lower being much the slenderer. There are four hairs on the lower part of the second joint, two on the inner edge rather stout and curving, and one fine one just below them, and a long one in front. On the last joint again are four hairs, all near the terminal claw, namely, a small one in front, a thick, curving one on the side, another thick, curving one just above the pad of the claw, and immediately above this the fourth hair, which is shaped something like an Indian club, and is apparently somewhat flattened. The constancy of form and disposition of these hairs lead us to think that their arrangement must be of some importance, therefore we have given this detailed description.

*Some material preserved in a 5 per cent. solution of chloral-hydrate was found very useful. With this preservative, specimens should be opened in several places to allow the fluid to penetrate into the interior. Indeed this should be done with alcoholic specimens also.

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The false feet or prolegs, Plate VI, Fig. 2, of which there are five pairs, the first pair considerably smaller than any of the others, as is well known, differ entirely from the true, anterior or permanent legs. They are thicker, cylindrical, and one-jointed; they have a few long hairs, and are armed with a row of a dozen and a half curved hooks. The hooks turn towards the median line of the body; they diminish in size from the center of the row towards each end. Each hook consists of a more cylindrical, large basal portion, which appears to be chiefly imbedded in the flesh of the foot, and a recurved hook proper, Plate I, Fig. 3, which has a very thick cuticula. There is also a pigmented pad, which lies over the base of each hook on the inside of the foot. We could find no certain evidence of a second row of hooks such as have been described in many caterpillars, though possibly there are very small claws on the pigmented pads above described.

The markings, colored stripes and dots, that decorate the larva, are produced by various means, partly by deposits in the matrix of the crust (epidermal cells), partly by colors of the crust itself. The dark-brown color belongs to the crust, and is peculiarly distributed in a manner that has not, so far as we are aware, been described hitherto. Upon the outside of the crust is a very thin but distinct layer, which in certain parts rises up into a great number of minute, pointed spines that look like so many dots in a surface view, Plate VI, Fig. 8. Each spine is pigmented diffusely, and together they produce the brown markings. The spines are clustered in little groups, one group over each underlying matrix, or epidermal cell.

The stigmata of the larvæ are small vertical fissures on the sides of the segments. The first, fourth, and subsequent segments have each a pair, making nine in all; there are none on the second and third rings. Viewed from the surface they are seen to be provided with an anterior lip, which is simple, and a posterior lip, which bears a projecting lever. Both these lie quite deep down and serve to close the trachea. Above each lip are several rows of hairs that are short, branching, and spine-like. The stigmata form the subject of a recent excellent memoir by Oskar Krancher,* a pupil of Rudolph Leuckart, the distinguished professor of zoology at Leipzig. On pages 543–546 of this essay the stigmata of caterpillars are fully described. According to Krancher, the lever-bearing, or posterior, lip is more developed than the anterior. (The former was named by Landois the *Verschlussbügel*, the latter the *Verschlussband;* but these names are not specially appropriate, and we prefer to use anterior and posterior lip instead.) The lever arises from the upper end of the posterior lip. In most of the diurnal lepidoptera it is a simple chitinous rod, but in some of the Bombycidæ it is more complicated. Attached to the lever is a double muscle; one part, running to the lower end of the lever-bearing lip, serves to approximate

* Oskar Krancher. Der Bau der Stigmen bei den Insekten. Zeitschr. f. wiss. Zoologie, XXXV, 1881, pp. 505–575, Taf. XXVIII–XXIX.

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the two lips, and so close the opening between them; the other part is attached to the neighboring epidermis, and serves to open the lips. Only this latter division of the muscle, which is considerably the larger, was described by Landois.*

The internal anatomy of the larva agrees closely with the lepidopterous type, as established by previous observers. In the head, Plate VII, Fig. 1, the digestive canal begins with the large mouth *m*, lined by a dark, firm cuticula and passing over into the narrow muscular œsophagus, *Oe.* Behind the mouth is a projecting pointed process at the tip of which opens the salivary duct. Above and in front of the mouth there is a distinct mass of tissue, of a fibrous, areolar character, spreading out fan-like from the upper wall of the œsophagus and attached in front to the lower part of the clypeus and to an endocranial process. In this mass of tissue lies the small frontal ganglion. Above the œsophagus is the brain, *br;* below it the subœsophageal ganglion *S*, connected by a short commissure with the first ganglion of the ventral chain.

The rest of the internal anatomy is illustrated by Fig. 1, Plate VI. In the first (thoracic) segment the œsophagus expands into the enormous stomach *St.*, which runs through eight segments, and is by far the largest and most conspicuous organ of the body. From in front backwards it gradually widens, but posteriorly it is rounded off. Into the hinder end open the malpighian or urinary vessels *m. v.*, six in number, three on each side uniting together and opening by a short duct. The salivary glands lie upon each side of the stomach, having long ducts which reach through the anterior three segments of the body. The gland proper, *Sal.*, is an elongated tube, gradually diminishing in diameter towards its posterior end or tip; its course is curious; it runs some distance straight backwards, then makes a sharp angle over the second proleg and runs forwards and upwards, then another sharp crook over the first proleg and it continues backwards again and slightly upwards. Behind the stomach the intestinal canal consists of four parts: first a short, constricted connecting piece; second a dilated, oval division, *In.;* third the short rectum *R.;* fourth the short anal tube. The dorsal vessel or heart, *d. v.*, is a long tube placed above the digestive canal, and extending through nearly the entire length of the body. The ventral chain of ganglia numbers eleven distinct knots, the last being however evidently double. The first ventral ganglion is the subœsophageal; the second lies so near it as to be almost united with it. The others lie at regular intervals, until the tenth, which is pushed a little forward of its original position over the fourth proleg. The eleventh double ganglion lies close to the tenth and gives off a large number of nerves, most of which run backwards.

The large stomach alone represents the entodermic canal, and presents

* Landois. Zeit. wiss. Zoologie, 1867.

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the same essential peculiarities of minute structure as were described by Minot* in the orthoptera. The lining epithelium is thrown up into folds so as to form imperfectly differentiated glandular follicles. If the epithelium be brushed off, the characteristic arrangement of the muscular fibers can be seen, Plate VI, Fig. 7. There is an internal coat, composed of a great number of pale fibers running transversely around the stomach and more or less parallel to one another. Outside are the longitudinal striped muscles, which are distributed in single bundles, *l l*, and do not form a continuous layer. Each bundle is composed of a number of fibers and pursues its own course; the bundles are not parallel, but sometimes two bundles unite, or are connected by a third; their general trend is longitudinal. Finally it must be mentioned that numerous tracheal branches penetrate the muscular layers, and ramify through both them and the connective tissue.

EXTERNAL ANATOMY OF THE IMAGO.

To prepare the external skeleton for examination the following method is satisfactory and convenient. The whole insect, either in the fresh state or after preservation in alcohol, is placed in a test tube with a solution of caustic potash and carefully boiled over a flame for a couple of minutes. The specimen is then thoroughly washed with water, to which a little acetic acid or vinegar is added to neutralize the alkali. The specimen while in this state may be brushed with a camel's-hair pencil, and most of the scales removed. It is best to put it next, for twenty-four hours, in strong alcohol and to then complete the brushing upon the hardened object. With a little care and patience all the hairs and scales can be removed without injuring the crust.

A view of the exoskeleton of the female is given on Plate VIII, Fig. 1. We shall follow Mr. Burgess' memoir upon the Milkweed Butterfly,† as to the homologies and nomenclature of the parts. The head is more triangular in outline, when seen from the side, than in Danais, and the eyes, *E*, are relatively smaller. The palpi and maxillæ are very similar to those of the butterfly. The antennæ, *a*, are thicker and the enlargement of the two basal joints is quite marked. The thorax is large and compact. The first segment (I) is small, the second (II) by far the largest of the three. The prothorax is connected with the head by a narrow neck, which is perhaps really the anterior portion of the first thoracic segment. This point is better shown in a view of the underside, Plate IX, Fig. 1. The front legs are there removed; the insertion of coxæ into the thorax is shown at l^1; just in front of this insertion is a thickened ring of hard crust; farther forwards the integument is membranous, and the prothorax proper becomes directly continuous with

*Minot, C. S. Histology of the locust (*Caloptenus*): and the cricket (*Anabrus*): Chapter X, in Second Report of the United States Entomological Commission. 1880. Pp. 183–224. Plates II–VIII.

†Burgess, Edward. Contributions to the Anatomy of the Milkweed Butterfly (*Danais archippus*, Fabr.). *Annls. Mem. Boston Soc. Nat. Hist.*, 1881.

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the neck. So, too, a median section shows that the neck and prothorax are really one, Plate VIII, Fig. 2. Two pendulous lobes s^1, Fig. 1, Plate VIII, project from the upper side of the prothorax, which appear to belong to the scutum, but their real homologies are not yet determined with certainty. They are constricted around their bases, so as to be quite movable. Upon the sides, just behind and below them, lies the first spiracle, sp^1. Below the spiracle are two pieces of elongated shape, running down to the insertion of the coxæ; the anterior piece, eps^1, is the episternum, and meets its fellow on the ventral side, forming a median suture between the two coxal articulations, Plate IX, Fig. 1; the posterior is the homologue of the epimeron of the segments.

The mesothorax, Plate VIII, Fig. 1, II, is the largest segment of the body. It is longest on the upper side. The principal dorsal piece is the big scutum, s^2, below the lateral edge of which springs the front wing, w^1. Over the base of the wing runs back the large patagium, *pt*, which is very much developed; its only connection with the body is in front, where it bends over and, as it were, hooks around the front edge of the wing. The scutellum, sm^2, is also prominent and extends for some distance over the metathorax. The episternum, eps^2, is an oblong piece which runs backward, beginning just underneath the front end of the patagium, and is joined behind to the epimeron, epm^2. It is united below with a double piece, *st*, which extends downwards and backwards to the coxæ, cx^2. This piece was determined by Dr. Packard, in *Attacus*, as the sternum, and his nomenclature was followed by Burgess in his article on Danais. From our study of the Cotton Moth, it seems doubtful whether this interpretation can be sustained. The piece is double on each side, as can be especially well seen in a ventral view, Plate IX, Fig. 1. The same aspect also shows that the two pieces do not meet in the median line, but are separated by a clear triangular space, behind which lies a pair (*a*, *a*) of pieces which separate the coxæ and meet one another in the median ventral line. These are perhaps the real sternal pieces. In any case it is evident that further and extended study is necessary to elucidate the real morphology of these numerous components of the thoracic skeleton. The epimeron, epm^2 (Plate VIII, Fig. 1), is quite large and complicated. It consists of a hard V-shaped piece, between the two legs of which is a large, triangular membranous area. The anterior leg of the V is much the broader, and joins above to the episternum, and in front to the part marked *st*, which Packard has held for the sternum. The membranous portion between the legs presents an inconspicuous structure, which is perhaps a spiracle, although this could not be certainly established. The coxal joint, cx^2, tapers rapidly; examined from the outer surface it appears to consist of two pieces; the anterior piece has been called the *coxa*, the posterior the trochantine by some authors.

The metathorax (III) is particularly puzzling on account of its very complex structure, due at least in part to the development of numerous

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air-chambers in the interior, accompanied by manifold ingrowths of the outer crust to serve as partitions between the adjacent air-chambers. As the ingrowths are connected with divisions of the exoskeleton, this last becomes very complicated, especially in the posterior lateral region below the wing and above the leg. The scutum, s^3, is well marked; immediately below it arises the hind wing, w^2. The piece which Burgess determined as the scutellum in Danais we have not found in Aletia; but what in the butterfly appears merely as the tip of the scutum is distinctly differentiated in the moth and is very probably the true scutellum; in this case the part so named in Danais would have to be considered as the post-scutellum. On the front edge of the segment, between the front edge of the wing and the coxal joint, is a single piece, eps^3, which seems to correspond to the two pieces, eps^2 and st^2, of the mesothorax, fused into one. In the posterior part, epm^3, there are a variety of structures, of which the most important are two, marked *A* and *B*. The former is a little quadrangular flap, which hangs down from just below the posterior edge of the hind wings. The latter, *B*, is a deep-lying, oval, pellucid membrane, which we think is probably homologous with the tympanal membrane of grasshoppers. The relation of these parts is better shown in the enlarged figure, Plate XI, Fig. 3, in which the oval membrane, *B*, and the flap, *A*, are both very distinctly drawn. We have not succeeded in observing any spiracle on this segment. The boundary between the metathorax and the abdomen is not clearly marked externally. The coxal joint, cx^3, is similar to that of the second leg.

A. H. Swinton has published a paper on the organ of hearing in lepidoptera,* in which he refers to the oval disk, which we have interpreted as a tympanum. According to Swinton, a nerve passes from the third thoracic ganglion obliquely across and round the elevator muscle of the hind wing to the supposed tympanum, where it is connected with a structure (Swinton's "membranous vesicle") which is apparently identical with the structure in like position in the grasshoppers, which latter was likewise originally described as a vesicle, but is now known to be really a cluster of rod-bearing, terminal organs, such as are now known to be the essential constituents of tympanal organs. For a general account of these apparatus see the résumé by C. S. Minot.† It is probable that the part we have described in moths is a real tympanum, and entirely homologous with that of Acridians, but the matter must remain uncertain until the terminal rods have been actually found.

The abdomen consists of nine segments, numbered 1–9, the last two not showing in the figure, being retracted into the seventh segment. The first is smaller than the second and succeeding segments, and, therefore, appears as a sort of thick stalk uniting the abdomen with

* Swinton, A. H. On an Organ of Hearing in Insects, with special reference to the Lepidoptera. Entomologist's Monthly Mag., XIV (1877), 121–126.

† Minot, C. S. Comparative Morphology of the Ear. Fourth Article. American Journ. Otology, IV (1882), 89–168.

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the thorax. Each of the segments consists of a dorsal, two lateral (one on each side) and a ventral piece. The side piece or membrane of the first seven segments bears a spiracle. The first segment, in its transverse diameter, is nearly as broad as the thorax, but its dorso-ventral diameter is barely half as great. In front it bends over and inwards, especially at the sides, so that here (see Plate XI, Fig. 3) the crust, where it joins the thorax, faces towards the head. It is here that the spiracle (*sp*) is placed, so that in a side view of the abdomen we see the edges of the spiracle, and not its opening, as in the other segments; the spiracle looks forwards.

The structure of the spiracles is interesting. They are all essentially alike. Plate XI, Fig. 1, represents that of the second abdominal segment. The spiracle is a vertical fissure with two lips, of which the anterior is connected with a long tendon, to which are attached the muscles which move the lips. Outside the lips is a row of stiff hairs, or spines, which, standing out from the borders of the fissure, reach towards its center, so that those of the opposite sides nearly meet in the middle. Fig. 2 of the same plate gives a more magnified representation of a single spine. It rises from a pore-canal (or tube running through the cuticula), makes a bend at the start, and then runs out nearly straight, a thick stem, from the outer half of which arise a number of oblique prickles or thorns irregularly placed. The shaft consists of a hard sheath and a core or pulp. The hairs on the front edge are a little shorter than those on the posterior. At the top and bottom of the fissure the hairs become very small. The purpose of these spines is undoubtedly protective; they serve to prevent the entrance of foreign bodies, like the similar structures in the spiracles of the caterpillar. In the adult there is a single row of long spines; in the larva several rows of short spines.

The legs offer little requiring special description. The tarsal joints are five on each leg. After removal of the scales they are seen to be armed with a double row of spines on their inner margin (Pl. IX, Fig. 2), except the last joint, which has only hairs. The spines are shortest on the upper part of each joint and increase towards the distal end, the lowest spine being the longest. The end of the last joint bears in front two long, curving hairs, and behind the two recurved hooks, between which is placed the soft hairy pad, or pulvillus, *p*. The other joints are distinguished by their gradual diminution in length, the first or upper being the longest and having also the largest number of spines, as well as the greatest intervals between the adjacent spines. The scales on the legs are peculiarly grouped, being inserted in little clusters of some 10 to 15. Each cluster is very compact and elongated, in the sense of the long axis of the limb.

The scales are flattened hairs, divided into a blade of variable shape and a short pedicel, by which they are attached to the skin. The blade consists of a central portion, homologous with the core of hairs, and

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a cuticular membrane, consisting, of course, of an upper and lower lamina, united at their edges and continued on the pedicel. Burmeister gives it as his opinion that the scale is empty between the two laminæ; but we cannot accept his view, because in those scales we have examined there is always an internal pulp, which often contains coloring matters. The scales have longitudinal striæ, which are produced by folds of the *outer* surface or lamina, as is at once shown by a cross-section of a scale (Plate IX, Fig. 1A). The upper surface is more nearly flat. The lower surface is recurved on each side. The scales are thickest in the middle line and thin out towards the edges. All these features were likewise observed by Burgess in Danais, and it is probable that they are common to the majority of the lepidopterous scales. There has been much dispute concerning the nature of the striæ on the scales, and Burgess was the first to describe their real character. Certainly Burmeister is in error when he says: "Il n'est pas douteux que les stries bien visibles des écailles soient des filets élevés au côté interne de la lame supérieure, se prononçant au côté externe seulement comme stries finement imprimées."* In many species, especially of butterflies, there are transverse striæ, which are said by Burmeister to be confined to the inferior lamina. In conjunction with the longitudinal striæ, they divide the scales into little squares. There is great variety in the form of the scales, but the study of these variations has hitherto borne little fruit. R. Schneider has published a memoir† on the form and distribution of the scales over the body in Lepidoptera, treating the subject with considerable detail. More interesting is Burmeister's essay, which contains the best general account with which we are acquainted.

The scales are inserted into peculiarly-shaped oblique pore-canals (Plate XI, Fig. 5). They begin on the outer surface with a wide open funnel that leads into a bulb or spherical dilatation of the pore. From the deep-lying surface of the bulb runs inward a fine tube. Apparently the stalk of the scale fits into the outer funnel, and is attached to the bulb.

The distribution of the scale pores is characteristic; they lie in little groups, which tend to spread out in lines having the same general trend, but never strictly parallel with one another (Plate XI, Fig. 4). On the legs, as already mentioned, there is a similar grouping, though not identical with that shown in Fig. 4. On certain parts, as, for example, the patagia and the membranous portions of the thoracic crust, the pores are scattered more evenly, each by itself.

The best account of the structure of the maxillæ, or proboscis, of butterflies is that given by Burgess, and an examination of this organ in Aletia reveals the same essential structure as in the butterfly, so that we may dispense with a detailed account. Plate XI, Fig. 6, represents

* H. Burmeister. Description physique de la République Argentine. Tome cinquième. Lépidoptères. (Examen spécial des Écailles, pp. 21–28.) Buénos-Ayres, 1878.

† R. Schneider. Die Schuppen an den verschiedenen Flügel- und Körpertheilen der Lepidopteren. Zeitschr. f. d. gesammt. Nat.-Wiss. III (1878), pp. 1–59, Taf. I–III.

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just the tip, to show its peculiar outline and the spine-like structures, which probably have a sensory function. They are present in all Lepidoptera, but under a great variety of forms; in Danais they are reduced to small warts, but in many other genera they are large and conspicuous; for details the reader may consult Darwin and Breitenbach.* The spines are evidently modified hairs, for they are each placed over a wide pore-canal of the cuticula, and are themselves pointed chitinous tubes, as shown in the figures (Plate XI, Figs. 6 and 8). The spines consist of two parts, a cylindrical basal joint and a double outer portion, composed of two tapering horns (Plate XI, Fig. 8). In some of the larger spines one of these horns is much the greater of the two, and seems to be a direct, spur-like continuation of the base, while the shorter fork is articulated to the proximal joint. In the smaller spines the inequality of the two forks is much less; the long fork is most developed on the spines of the dorsal side of the maxilla. There is difficulty in making out these characteristics in all the spines, as they often lie on the slide in positions unfavorable to microscopic examination, and there remain many points undecided. The largest spines are found a little way from the tip; on the very tip of the trunk they are a little smaller, and towards the base of the proboscis they gradually grow smaller and smaller, and lie further apart; they are not found on the basal half of the organ. Upon that edge of the maxillæ which is dorsal when they are extended, are hairs such as are represented in Plate XI, Fig. 7. These hairs are for the most part inclined away from the tip-like barbs. Whether they are stiff, so that they serve to lacerate the flowers attacked by the moths, we were unable to determine; that this function is performed by the large spines is, we think, improbable, although Professor Comstock has suggested this view.

INTERNAL ANATOMY OF THE IMAGO.

The digestive canal of Aletia closely resembles that of the Milkweed Butterfly, *Danais archippus*, as described by Burgess. We shall therefore follow his account.

The canal traversing the proboscis opens into a large muscular pharynx, which occupies much of the lower part of the head, Plate VII, Fig. 2. The pharynx is oval, and is suspended by at least two pairs of muscles, one dorsal, m^1, and one frontal, m^2. At the anterior border of the pharynx is a triangular muscular flap, the epipharynx, m^3, overlying the opening of the proboscis, and serving as a valve to close the latter. The pharynx shows two layers of muscles, an outer, thicker one of longitudinal fibers, and an inner of transverse fibers. The pharyngeal cavity extends obliquely upwards from front to back, and is much broader than high.

"The pharynx, as is evident from its structure, serves as a pumping

*F. Darwin, Quart. Journ. Micros. Sci., XV, 385. Breitenbach. Arch. für mikros. Anat., XV, 8, and XVI, 206. Jena, Zeitschr. f. Nat.-Wiss.

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organ to suck the liquid food of the animal through the proboscis, and force it backwards into the digestive canal, the process being as follows: The proboscis is unrolled, and inserted into the nectary of a flower; at this moment the muscles which suspend the pharynx contract, and its cavity is thus extended, creating a vacuum, which must be supplied by a flow of honey through the proboscis, into the pharynx. When the latter is full its muscles contract, the valve closes the aperture to the proboscis, and the honey is forced backward into the œsophagus. The pharynx is then again opened, and the same process is repeated. To prevent the food being sucked back from the œsophagus, it is probable that some of the numerous fibers in the muscular sac near the origin of the former can, by contraction, close its opening; but in any case, as the proboscis presents a free tube, and the œsophagus leads into the closed alimentary canal, it is evident that the former offers the easiest route for a supply to fill the vacuum produced in the pharynx." (Burgess.)

The organ just described escaped the notice of entomotomists until discovered by Burgess, and its functions were conjecturally ascribed to other parts. "The so-called 'sucking stomach' thus received its name from earlier writers, and when its structure was better known and such a purpose negatived, the capillarity of the fine tube of the proboscis, and even a peristaltic action of the latter, have been suggested to explain the power possessed by the butterfly to suck up its food."

At the upper extremity of the pharynx opens the narrow œsophagus, *oe*, and at the lower edge of the hypopharynx the common duct of the salivary glands, *sal*, discharges into the expanded base of the proboscidean canal. These glands consist of two long convoluted tubes, extending along each side of the thoracic central nervous system. In the general figure, Plate VIII, Fig. 2, the glands have been removed, in order to show the course of the œsophagus and ganglionic chain.

The œsophagus, Plate VIII, Fig. 2, *oe*, is a slender and delicate tube leading from the pharynx above, and after piercing the nerve commissure between the brain and the succeeding ganglion, passes straight through the thorax into the abdomen, in the very base of which it separates into two short branches, the upper leading into the food reservoir, the other the true stomach.

The *food* reservoir, *fr*, (or so-called sucking stomach), is a large membranous sac filling the anterior end of the abdomen; its walls are a very delicate cuticle, which is interiorly thrown into very curious labyrinthine wrinkles; near the neck is a region armed with singular processes or spines, scale-like in shape, each scale being armed with some six or eight very sharp teeth. The neck has an investment of transverse, annular muscular fibers.

In alcoholic specimens the food reservoir is much crumpled, and in all specimens opened was empty. There are some indications that the sac is not a simple one, but has secondary lobes or partitions; but this

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point is still unsolved. Since the organ is not for sucking, as long supposed, and is evidently not digestive, it seems likely, or at least possible, that it serves simply as a reservoir. It is first developed in the pupal stage.

In a lateral view, as in Fig. 2, the neck of the reservoir is concealed by the anterior end of the stomach, which projects into two short lobes on each side of the neck.

The stomach, *st*, is very much smaller than in the larva, for it barely extends through four abdominal segments. Its walls have the same two muscular coats as we have described in the larval stomach, *vide supra*, and the epithelial lining is thrown up into beautiful glandular corrugations. The stomach is overlaid with the convoluted malpighian vessels, *mv*, six in number, three of which, on each side, unite and open by a short, common duct into the posterior end of the stomach. At the end of the stomach begins the peculiarly coiled small intestine, *i*, which passes to the left of the bursa copulatrix in the female, and of the genitalia in the male. The intestine passes into the wide terminal division, or rectum, *R*, from the front end of which runs out a curved blind pouch or cæcum, *c*. In Danais the terminal division is clearly separated into an anterior part or colon, and a posterior part, or true rectum, but the rectal region is less noticeable in Aletia.

The course of the aorta, or anterior extension of the heart, in lepidoptera, was not correctly described by the older authors. Burgess observed its strange bend in the butterflies, and has since studied it in several forms of lepidoptera, and published his results in a short paper.* In this article he describes and figures the course of the thoracic aorta in a noctuid. In Aletia it enters from the abdomen behind, bends immediately upwards, widens rapidly, makes a slight crook, and then, reaching the dorsal wall of the metathorax, to which it is secured by fibrous tissue, it makes a sharp bend and runs back upon its own course; next curves forwards, and, growing gradually narrower, runs along just above the œsophagus into the head, passing with the former through the brain.

The nervous system consists of a chain of ganglia and the nerves. The supra-œsophageal ganglion, or brain, occupies nearly the center of the head (Plate VII, Fig. 2, *Br.*), and is connected by very thick commissures with the sub-œsophageal ganglion, which passes gradually into the cord that leads to the first thoracic ganglion. This is quite distinct, but the second and third are almost completely fused, and connect with the abdominal ganglia by a very long commissure. In the abdomen (Plate VIII, Fig. 2) there are four nerve centers (*a. g.*, *a. g.*), as is almost always the case in the Lepidoptera, lying in the third, fourth, fifth, and sixth segments respectively. The last is the largest, and is compounded of two or more ganglia fused together; the principal nerves arising from it seem to innervate the organs of reproduction.

*Burgess. E. Proceedings Bost. Soc. Nat. Hist., XXI, 153–156.

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TERMINAL BODY SEGMENTS AND ORGANS OF REPRODUCTION.

In the state of rest the eighth and ninth segments in the abdomen of both sexes lie concealed within the seventh, the intersegmental membranes in these cases being long enough to admit of this telescoping action. The eighth segment of the male does not differ from the preceding, except in wanting the spiracles and in its smaller size. It has, however, on its under side a thick shock of long hairs or scales parted down the middle, which, when this segment is retracted within the seventh, serves to form a soft cushion between the two, although this may not be its only purpose. The brushes of hair, to be described below, borne by the ninth segment act in the same manner as a cushion between the eighth and ninth segments.

The dorsum of the latter or terminal segment is produced backwards into a slightly curved hook, often compared with the telson of the crustacea (see Plate VIII, Fig. 2, and Plate X, Figs. 1 and 3, where the hook is marked with the figure 9). This hook covers the anal opening (*a.*), and in some Noctuids is greatly developed. Beneath it is a chitinous finger (Fig. 3, *f*) which is movable, but its function is obscure.

The ventral portion of the ninth segment forms a broad trough-shaped process (Plate X, *v. pr.*, Figs. 1–3), with upturned lateral edges, the penis lying in the bottom of the trough so formed, and hinged to each side of this segment are the "claspers," which are narrow triangular pieces with a slender, slightly incurved apex. Their exact shape will be more readily understood by referring to the lateral, dorsal, and ventral views given in Plate X, Figs. 1, 2, and 3, *c* left, *c'* right clasp.

There is still another and singular organ attached to the ninth segment. This is a sac with delicate membraneous walls thickly covered with slender, long-stalked scales (Plate IX, Fig. 3). The sac is very elastic, and may be protruded like a long finger and again retracted at will. The long hair-like scales give the organ the appearance of a brush. It is shown in various positions on Plate X, Figs. 1–3, *b*, the scales being removed in all the figures. This brush-sac is attached to the base of the claspers.

Morrison* first called attention to similar organs in *Leucarctia acræa*, and states they are protruded by being filled with fluid from within. He also noticed them in Danais, Agrotis, and Euplexia. Burgess (*loc. cit.*) described their structure in Danais, where, however, they are not placed in the same position as in Leucarctia and the Noctuids. The retractor muscle found in Danais we have not succeeded in finding in Aletia. Müller has also noticed these appendages, and regards them as scent organs. At all events it is probable they are organs for sexual excitation. They are not found in the female.[33]

The male organs of reproduction consist of a very large *testis*, two *vasa deferentia*, in each of which a tubular gland opens, a *ductus ejacu-*

* Morrison, H. K. Psyche, I, 21.

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latorius, and the *penis*. The testis is shaped like a very thick, nearly spherical, button. (Plate VIII, Fig. 2, and X, Fig. 1, *Te.*) It is really a compound organ composed of two testes fused together. The testes can be found in the caterpillar as separate kidney-shaped organs lying close under the dorsal vessel* in the fifth abdominal segment. In both larva and imago the fifth abdominal spiracle sends a branching tracheal tree which spreads over and into the testes on each side. The vasa deferentia lead from the posterior face of the testes. After a few convolutions they dilate into pod-shaped chambers, and then contract for a length of very fine tubes until reaching the point of union with the *glandulæ mucosæ*, into the basal portion of which the vasa deferentia seem to open. A short distance farther and the two vasa deferentia unite into a long, single duct, the *ductus ejaculatorius*, which is of larger diameter, contracting slightly near its end, again dilating into a very muscular, gourd-shaped section (Plate X, Fig. 1), which opens into the penis.

The latter organ is a slender, chitinous tube whose top projects between the claspers and below the anus, and which lies in the trough formed by the ventral arch of the ninth segment, as already described. It is protruded by a muscle on either side, the *protractor penis*, which is attached to the ninth segment. The end of one of these protractors is shown at *pp* in Figs. 1 and 2, of Plate X. The retractor was not found. From the tip of the penis project two prongs, which bear on their inner aspect several stout spines and some smaller teeth, as shown in Fig. 4, Plate X. These prongs seem capable of protrusion and retraction, and telescoped within the penis can be seen other chitinous processes and spines, apparently of considerable complexity, which could not be satisfactorily studied in the specimens at disposal.

FEMALE ORGANS OF REPRODUCTION.

The ovaries consist of four long slender tubes, lying in several folds on each side of the body. Their slender tips end in suspensory ligaments, all eight of which unite together immediately under the dorsal vessel. At their basal ends the ovarian tubes of each side unite into a uterine chamber (Plate IX, Fig. 4, *u.*), the short oviducts from which unite into a single oviduct, which passes through the eighth and ninth segment and opens between the lateral flaps of the latter beneath the anus.

Two accessory glands—colleterial or sebaceous glands, so called—which are concerned with secreting the egg-shell or the cement by which the moth fixes the eggs in place when laid, open into the common oviduct. The anterior gland is single; the posterior is a pair of glands with a single duct. Both consist of long cœcal tubes, with pear-shaped dilations near the base, followed by another roundish dilation. (See

*See Meyer. Zeitschr. wiss. Zool. I, 182. Also H. Landois, *Ibid.*, xiii, 316.

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Plate IX, Fig. 4, *a. gl.*[1] and *a. gl.*[2]) The paired glands lie close under the rectum, and would at first sight be supposed appendages of the latter instead of belonging to the oviduct.

At the base of the eighth segment, beneath, opens the vagina (*v.*), the orifice of which is therefore distinct from that of the oviduct. It is a long horny canal, which leads into a very large pyriform copulatory pouch. (Plate IX, Fig. 4, *c. p.*) This pouch is a very remarkable organ in the Lepidoptera. Its walls are very thick, and consist of a powerful muscular layer (Fig. 7, *m.*), within which is an epithelial layer (*sp.*) or matrix which gives rise to a stout *cuticula intima* (*cu.*). This last lies in heavy folds or ridges (Fig. 5), which have a general longitudinal direction, but with various curves and anastomosing branches. It is covered with little points, or teeth, which are stouter near the base of the pouch, and similar to the cuticular spines of the larval skin described at the beginning of the chapter. Each point arises in a little field of its own, separated by various-shaped boundaries from adjoining fields. (See Fig. 6.) These fields probably correspond to the underlying cells of the matrix. Near the base of the interior of the pouch a transverse triangular flap or valve is suspended from above, very thickly covered with short teeth, like those over the rest of the pouch.

There is a deep longitudinal furrow on the top of the pouch, so that cross-sections of the latter give a Y-shaped cavity. The vagina itself has a smooth, stout cuticula. Near the base of the vagina a slender sperm-duct (*s. d.*) leads from the vagina into the oviduct, through which duct the spermatozoa pass from the copulatory pouch, where they are discharged into the oviduct where the eggs are to be fecundated. The sperm-duct does not expand into a spermatheca, as is often the case.

In the female, as in the male, the two terminal segments are retracted, resting within the seventh, and do not bear spiracles. The eighth segment is like the preceding in shape, but smaller, with the pocket beneath for the vaginal opening, as described. From the anterior margin, each side, a stout spur projects into the interior of the abdomen (Plate IX, Fig. 4) for the attachment of muscles to move the segment.

The dorsum of the ninth segment forms merely a membranous covering over the rectum and contains no ossified element. The sides of the segment are produced into two lobes (see Plate IX, Fig. 4), which flank the oviduct and form a short ovipositor. Anteriorly the lobes send out two spurs like those of the preceding segment, but they are not shown in the figure. Ventrally the segment terminates in a short triangular piece projecting between the lateral lobes.

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CHAPTER VI.

THE COTTON BELT.

By Prof. EUGENE A. SMITH.

[Maps I and II.]

A.—GENERAL FEATURES OF THE COTTON STATES.

In this region are included North and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, the eastern parts of Texas and the Indian Territory, Arkansas, Southern Missouri, Tennessee, and parts of Kentucky and Virginia. To these may be added, in California, the region between Merced and Kern in the southern part of the State, and Yuba, Sutter, and Colusa Counties in the northern part.

Almost the whole cotton crop is thus produced in the area included between the twenty-ninth and thirty-seventh parallels of north latitude, and between the seventy-sixth and one hundredth lines of west longitude.

CLIMATE.—*Winds.*—As regards the direction of the prevailing winds, the cotton States may be arranged in four groups.

The first of these includes Texas, Arkansas, and the Indian Territory, in which the prevailing winds during the summer are from the southeast, south, and southwest, and from the north and northwest during the winter months. The second includes the States of Kentucky and Tennessee, lying between the Mississippi and the Appalachian chain, in which the prevailing direction of the winds, both winter and summer, is from the southwest. The third includes the States of the Atlantic slope—North and South Carolina and Georgia—whose prevailing summer winds are from the southwest and those of the winter from the northwest. The fourth section, including the Gulf States, Louisiana, Alabama, and Florida, partakes of the characters of the other regions surrounding it; and, while the prevailing winds are southeasterly in summer and northeasterly in winter, the directions are very nearly evenly balanced, except in some parts of the Florida peninsula, where there is a very decided prevalence of easterly winds throughout the year.

Rainfall.—The supply of moisture for the rainfall over the cotton States comes almost exclusively from the Gulf of Mexico. The amount of yearly rainfall varies between the extremes of 28 and 64 inches. Over the greater part of this area it varies between 40 and 60 inches.

The densest part of this rain distribution is over the Mississippi delta and vicinity, reaching the maximum of 64 inches in Southeast Missis-

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sippi and Southwest Alabama, whence it divides, running with 56 inches northeastward to Florence, Alabama, and northwestward up the Red River to the lower part of Arkansas.

The annual precipitation over the rest of the cotton States is between 44 and 56 inches, with the following exceptions:

(1.) In Texas the rainfall is much less, varying between 28 and 44 inches in the cotton-producing portion of the State, and falling as low as 20 inches or less towards the west. The Indian Territory presents nearly the same characters.

(2.) Through Western North Carolina and East Tennessee, and extending down through Georgia and Southeastern Alabama into Florida, there is an area in which the precipitation is between 40 and 44 inches. A narrow strip along the coasts of North and South Carolina exhibits similar conditions.

(3.) In the extreme south of Florida (outside of the cotton region) there is a rainfall of 56 to 60 inches.

Of great importance to the growth of the cotton plant is the distribution of the rainfall over the different seasons; and we find the maximum of precipitation during the months of June, July, and August, of 18 inches and above, (1) in the delta region of the Mississippi, and extending in a narrow band up the Mobile River, into the fork of the Tombigbee and Alabama Rivers; and in a second narrow band northwestward almost to Little Rock, Ark. (2) Eastern South Carolina and Georgia, and the whole of the *peninsula* of Florida, show similar conditions, the summer rainfall in Southwestern Florida reaching 28 inches.

The rest of the cotton-producing area has a summer precipitation varying between 10 and 18 inches, excepting parts of Texas and the Indian Territory, where it is less.

As regards the winter rainfall, we find, as in summer, the densest area about the Mississippi delta, 12 to 18 inches, whence it spreads northward in three bands—one through Central Alabama and Georgia and along the eastern slope of the Appalachian chain; the second, passing through Northwest Alabama and Northeast Mississippi, crosses Central Tennessee and Kentucky in the direction of Cincinnati; the third passes up the Mississippi River, mainly to the west of that stream, to the latitude of Cairo.

A second area, of above 12 inches, is seen in Texas, passing through Indianola and Austin, and a third in Middle Florida, east of Appalachee Bay.

The rest of the cotton-producing area has a winter rainfall varying between 8 and 12 inches, excepting the western part of Arkansas, most of the Indian Territory, a good part of Texas, and a portion of the eastern part of the Florida peninsula.

It is impossible to trace any very close relation between the rainfall and the percentage of area planted in cotton, but it may be noted that

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those parts where this percentage is 10 and above have a summer rainfall *below* 14 inches, and a winter rainfall *above* 12 inches.

TEMPERATURE.—The distribution of heat in the cotton States is nearly normal, as the isothermals follow approximately the parallels of latitude, the departures from this regularity being due (1) to the heating effect of the Gulf Stream, by which the lines of equal temperature are elevated or deflected northward along the Atlantic coast; (2) to the cooling effect of the mountains, which causes a depression southward of these lines, as may be seen in the vicinity of the Appalachians; and (3) to the accumulation of heat in valleys, which carries the isothermals up these valleys, often to considerable distances beyond their normal position. With these general principles in view, it will be easy to understand the temperature distribution in the region of which we are writing.

The mean annual temperature line of 68° Fahr. runs nearly parallel with the southern coasts of Alabama, Mississippi, Louisiana, and Texas, where these coasts have an east and west direction, and at no great distance north of this shore line. In Texas it is carried up the Rio Grande Valley, beyond the 102d degree of west longitude.

The line of 64° follows approximately the parallel of 33°, running north of it near the coast in North and South Carolina, because of the Atlantic Ocean; south of it in Georgia and Alabama, because of the influence of the Appalachian chain; it is carried upward by the Mississippi and Red River Valleys, bending downward on each side of them, being deflected far to the south beyond Red River, in Central Texas, by the influence of the western mountains.

The line of 60°, starting from the coast of North Carolina a little north of the 36th parallel, crosses that State diagonally to the eastern foot of the Appalachian range, around the southern end of which it sweeps in a great curve which passes below Talladega in Alabama, and bends northwestward to New Madrid, Mo., whence it runs westward approximately along the 36th parallel through the Indian Territory into Texas, till turned southward like the preceding in the western part of that State.

The isothermals between 52° and 56° lie generally north of the cotton States, except in the Appalachian region of North Carolina, Tennessee, Georgia, and Alabama, and the central parts of Tennessee and Kentucky, but in none of these localities is the production of cotton on any large scale, except in Western North Carolina, the valley of the Chattahoochee in Georgia, that of the Tallapoosa, Coosa, and Tennessee in Alabama, and a part of the central basin of Tennessee, where the mean annual temperature is between 56° and 60°.

The isothermals for the summer are far less regular than those of the year. Thus the summer line of 80°, starting at the coast near Charleston, runs westward to Macon, Ga.; thence south to Tallahassee, Fla.; thence diagonally across Alabama to Tuscaloosa, to which it is raised

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by the Alabama and Tombigbee Rivers, and though partly kept up by the Chickasawhay and Pearl Rivers, bends then south nearly to Baton Rouge. Up the Mississippi Valley it is carried nearly to the 35th parallel, and after sinking below the 33d, is carried again by the Red River Valley beyond the 35th parallel in the Indian Nation, whence it bends around southwest approximately parallel to the Texas coast, till carried far out to the west along the Pecos and Rio Grande.

The rest of the cotton-producing territory of the United States is included between the summer lines of 76° and 80°, excepting where the Blue Ridge in Western North Carolina and Northern Georgia and the Cumberland Mountains of Tennessee cause a great southward extension of the summer mean of 68° to 72°, and where, along the eastern slope of the Blue Ridge in North Carolina and Georgia, around its end in Alabama, and between the Blue Ridge and the Cumberland ranges in the valley of East Tennessee, and on the western slope of the Cumberland in Middle and Western Tennessee and Kentucky, and southward on the water-shed between the Tombigbee and Yazoo in Mississippi, the mean summer temperature is between 72° and 76°.

In view of the probable influence of the winter temperatures in determining the place of hibernation of the cotton moth, it has been thought best to transcribe upon one of the maps accompanying this article the lines of equal temperature, during the winter months, for every fourth degree, from 28° to 72° Fahr. These lines, as well as the data upon which the above account of the climate of this region has been compiled, have been taken from the Smithsonian Contributions, Vols. XVIII, XX, and XXI.

It will be seen that these winter lines show the comparative regularity of those of the annual means; they are carried northward by the influence of the Gulf Stream along the Atlantic coast, and by the various large rivers in the west, while they are carried southward by the mountains and high table lands.

The chart, however, presents all these facts much more clearly than can be done by any verbal description.

GEOLOGICAL SKETCH.—Through North and South Carolina, Tennessee, and Georgia passes the great mountain chain of the Appalachians, terminating in Central Alabama. The most elevated parts of this chain, and its southeastern or Atlantic slopes, are formed of the crystalline or metamorphic rocks, while the opposite or northwestern slope is made up of the strata of the Silurian and other Paleozoic formations.

Westward of the Appalachian region of elevation these Paleozoic rocks underlie the country to the central part of Texas, not, however, continuously through the cotton-producing States, but interrupted by one great gap, which reaches up the axis of the Mississippi River as far as the mouth of the Ohio.

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The outer margin of these older formations is near the following towns: Raleigh, Columbia, Augusta, Macon, Columbus, Wetumpka, Centerville, and Tuscaloosa, whence it turns northward through Tennessee, meeting the present Mississippi at Cairo, and thence through Little Rock southwestward as far as Central Texas.

In the waters off the sinuous shore-line, thus outlined, of the ancient continent were deposited in succession the sediments which constitute the newer formations, Cretaceous and Tertiary. By the gradual elevation of this part of the continent these deposits were added to the land area already existing, and the shore line moved outward, at least as far as its present position.

By a subsequent depression these newer formations, and the lower edge also of the older, were submerged and covered with deposits of sand, pebbles, clay, and loam, brought down from northern latitudes.

Upon these deposits some of the cotton States depend for their most important soils, and they will hence be again subject of special mention below.

Lastly, a re-elevation gave to the continent its present outlines.

TOPOGRAPHY.—The really mountainous portion of the cotton States is confined to the Appalachian region, in which the strata have been thrown into folds, faulted, and elevated many hundred feet above the general land surface. The main topographical features of this region conform in direction to that of the folds originally impressed upon its strata, *i. e.*, northeast and southwest. The unyielding nature of many of the rocks and their alternation with others more easily eroded have likewise had their influence in determining the character of the scenery.

This region, as already stated above, is composed partly of the metamorphic rocks, and partly of the uncrystallized Paleozoic strata. The highest mountains of this chain are formed of the crystalline slates.

Outside of the Appalachian region the Paleozoic rocks are approximately horizontal, and, where they make the country, the topography is the result of erosion simply, and is very little, if at all, modified by the geological structure.

This whole area has a gentle slope away from the Appalachian axis, and there are nowhere within its limits elevations of any considerable magnitude as compared with those of the preceding division.

The presence of sandstones and beds of hard cherty limestone among these strata gives rise, however, to varied scenery of the most pleasing character.

The newer rocks have a gentle dip away from the Paleozoic border. Their elevation is in general less than 600 feet above the sea, and the scenery, as in the preceding instance, is solely the result of erosion.

The mantle of sands and loams which covers these newer rocks gives additional uniformity to the topographical features, which are almost entirely independent of the character of the underlying beds. The broken and almost mountainous region produced by the hard sandstones

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of the Lower Tertiary, and the low basin or trough of the Cretaceous are the principal exceptions to this uniformity.

Through all this region of the newer rocks there are alternations of nearly level table lands of 500 to 600 feet elevation above tide, bordered by red clay and pebbly hills where the table lands break off towards the water courses.

The most recent formations, along the alluvial plains of some of the larger rivers and in the vicinity of the Gulf coast in Texas and Louisiana, have almost a dead level surface.

The topographical features are thus seen to be in great measure, and particularly within the hydrographical basin of the Mississippi, the result of erosion simply.

The drainage of the greater part of the cotton-producing area is into the Gulf of Mexico, and the Mississippi River the principal channel.

The waters of the Carolinas and Eastern Georgia and Eastern Florida find their way into the Atlantic.

SOILS.—The soils which are planted in cotton may be divided into two great classes.

Those of the first class rest directly upon the rocks from which they have been derived, or at most have been very little removed from their original places; and hence they are in composition closely related to the underlying rocks, and vary from place to place as these vary.

The soils of the second class have been transported from their place of origin, and, as a rule, rest now upon rocks with which they have little or no genetic relation.

Resulting, as they do, from the commingling of the detritus of widely-separated and very different rocks, these soils, over great areas, present substantially the same features, irrespective of the particular geological formations upon which they have come to rest.

In general terms, the Paleozoic formations possess soils which have resulted from the decay of the rocks of the country, while the newer formations have been covered with a mantle of sands, pebbles, and loams, which have been brought from greater or less distances, and which in a great measure form the soils and subsoils over the entire area, with the few exceptions presently to be noticed.*

The drift soils above named, while similar in composition over large areas, are nevertheless in places modified by admixtures with the products of the disintegration of the underlying Cretaceous and Tertiary rocks, and in certain localities these disintegrated rocks themselves constitute the soils, as in the black prairie region of Alabama and Mississippi, and in some of the Tertiary prairies of these States.

* It is hardly necessary to say that, with reference to the Drift beds from which they are derived, these soils also are sedentary or in place, and the beds of the Drift are, accurately speaking, as much rocks as are, for instance, the limestones of the Silurian age; still, from our point of view, the distinction above made has its justification in its convenience.

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Near the coast in Louisiana and Texas, and in some parts of the alluvial region of the Mississippi and its tributary rivers, the Drift itself in turn has been covered with still more recent deposits, a kind of river-swamp or Gulf-swamp formation, from which some of the most important soils of these localities have been directly derived.

AGRICULTURAL SUBDIVISIONS.—The agricultural characters of the Cotton States may be described under the following heads:

1. *The alluvial region*, including—
   a. The alluvial region of the Mississippi and other large rivers.
   b. The marsh region of the coast and lakes.
2. *The lower prairie region*, including—
   a. The central prairies of Louisiana and the coast prairies of Texas.
   b. The prairies and savannas of Florida.
   c. The *llano estacado* and gypsum lands of Texas and the Indian Territory.
3. *The long-leaf pine region*, including—
   a. The long leaf pine hills and flats.
   b. The oak and hickory uplands with long-leaf pine.
   c. The hammocks of Florida; the shell prairies, lime hills, and red lime lands of Mississippi, Alabama, and Florida.
4. *The oak uplands region*, including—
   a. The oak and hickory uplands with short-leaf pine.
   b. The table lands of Mississippi and Tennessee, and the Cane Hills or Bluff region.
5. *The upper prairie region*, including—
   a. The black Cretaceous prairies of Texas, Mississippi, and Alabama.
   b. The blue marl lands and hill prairies (Pontotoc Ridge and Chunnenugga Ridge of Mississippi and Alabama).
6. *The red and brown loam region*, based on the older limestone formations, including—
   a. The red loam lands of the Tennessee Basin, of the valley of East Tennessee, of the Coosa Valley, and of the Tennessee Valley in North Alabama.
   b. The red loam uplands and prairies of Arkansas, Indian Territory, and Texas.
7. *The sandy and siliceous lands of the older formations*, including—
   a. The cherty limestone lands and "barrens" of Tennessee, Georgia, and Alabama; the cherty lands and their prairies of northern Arkansas.
   b. The Carboniferous sandstone soils of Alabama, Tennessee, and Georgia.
   c. The sandy prairie region of Indian Territory.
8. *The gneissic region.*

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Before proceeding to the description in detail of the agricultural regions above enumerated, it will be convenient to give a short account of the chief botanical characters of the different parts of the cotton-producing area, and this I am enabled to do through the courtesy of Dr. Charles Mohr, of Mobile, Ala., special census agent, to whom I am indebted for the following notes. It is proper to state that these notes refer particularly to the States of Texas, Louisiana, Mississippi, Alabama, and Florida.

It will be seen that the regions of forest growth of Dr. Mohr correspond in the main with the agricultural regions above given.

REGIONS OF FOREST GROWTH.

a. More or less open oak woods, as they prevail on the highlands of Alabama, with *Pinus mitis* and *P. tæda;* the long-leaf pine, *P. australis*, occurring on the cherty and sandy ridges and on the quartzose ranges of the eastern part of the State. As upland oaks the following species are included: *Quercus prinus*, mountain oak; *Q. Muhlenbergii*, chestnut oak; *Q. tinctoria*, black oak; *Q. stellata*, post oak; *Q. nigra*, black-jack. The hickories are *Carya amara*, *C. tomentosa*, *C. porcina*.

The other accompanying trees are the various haws, the snow-drop tree (*Halesia*), the sour-wood (*Oxydendrum arboreum*), and several species of *Cornus* and *Ilex*. Various species of *Azalea* and huckleberries make up the arborescent and shrubby growth.

In the mountains bordering on the valley of the Tennessee and all the deeper valleys of the mountainous region of North Alabama, where the limestone prevails, large buckeyes (*Æsculus flava* and *glabra*) make their appearance, with the *Magnolia cordata*, and the cucumber trees (*Magnolia macrophylla* and *acuminata*) find here their fullest growth; and nowhere are found the black walnut, white oaks, black oaks, and poplars (*Liriodendron*) in greater perfection, associated with the linden or basswood. This region includes 6, 7, and 8 of the agricultural subdivisions given above.

b. Rich bottom lands as represented by the alluvial lands of the Mississippi River and the Mississippi and Yazoo Deltas, and the less heavily timbered flat lands of southwestern Louisiana. The cypress swamps follow the banks of the rivers in their lower courses (mostly below the 33d degree of north latitude, except in the extensive cypress swamps of the Yazoo Delta, which reach as high as 35°). These swamps have an average width of 3 miles on each side. In their courses northward the bottoms are more restricted, and consequently the cypress swamps are rarer and cover a smaller area. This region corresponds with our division No. 1 a.

c. The more or less level table lands, with rich soil, once covered with heavy forests of oaks, poplars, and beech, like the rich lands between the pine hills and bluffs bordering the Yazoo Delta, in central Mississippi. These are the table lands No. 4 b above.

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d. Of a similar character, but somewhat less heavy, is the tree growth upon the lands in central Alabama and eastern Mississippi, of the Cretaceous plain, corresponding to our subdivision No. 5 a, or the black prairie region. This region is now almost denuded of its original forest growth, as are also the lands of the preceding division; and it is only in the bottoms of the larger streams, more or less difficult of access, that the dense and heavy forests are still found untouched by the woodman's ax.

e. Prairies and grassy savannas, more or less wet, east of the Trinity River, and in the coast plains of southeast Texas and southwest Louisiana and the glades of Florida. High and dry ridges of live-oak scrub, with mesquite bushes, in the prairie region of western Texas. This division corresponds with No. 2 above.

f (a). Region of the long-leaf pine (*Pinus australis*).

In the coast plains of East and West Florida the long-leaf pine is associated with the Cuban pine, and on the most infertile and arid ridges, with the turkey oak (*Q. Catesbæi*). Open forests, with no undergrowth on the rolling lands; with a dense smaller growth of evergreens in the marshy depressions and along the streams, particularly towards the coast. These evergreens are Ti-ti (*Cliftonia ligustrina*), *Magnolia glauca*, *M. grandiflora*; various species of *Ilex*, *Illicium floridanum*, Vacciniums, *Andromeda*, sweet-leaf *Bumelia*, white cedar (*Juniperus thyoides*), &c. This is our division No. 3 a.

f (b). Upper pine region or region of mixed growth. On the siliceous ridges of the Drift and Tertiary, the long-leaf pine prevails. In the more fertile marly and calcareous lands, the upland oaks with various other deciduous-leaved trees preponderate and, mixed with some short-leaf pine and spruce pine (*P. glabra*), form dense and often heavily timbered woods. The undergrowth is mostly heavy. This is our division No. 3 b.

g. Region of the short-leaf pine (*P. mitis*). The latter in eastern Texas often replaced by the loblolly pine (*P. tæda*). Pines largely prevailing with oaks and mockernut and pignut hickories (*C. tomentosa* and *C. glabra*). Undergrowth mostly dense. This is No. 4 a.

h. The more or less stunted oak woods covering the gravelly and sandy ridges on the borders of the arid prairie region of western Texas. Mostly black oak, post oak, and blue-jack (*Q. cinerea*). This would correspond, in part at least, to the red loam region, No. 6 c.

B.—DESCRIPTION OF THE AGRICULTURAL SUBDIVISIONS.*

1. THE ALLUVIAL REGION.

This region embraces some of the most fertile lands of the Cotton States, and the most serious trouble connected with their cultivation arises from their liability to be submerged at certain seasons of the year.

*In the preparation of this description I have made free use of the material collected under the auspices of the Census Office for Dr. Hilgard's Report on Cotton Production; but I am under special obligations to Dr. R. H. Loughbridge for notes on the agricultural characters of Texas, Arkansas, and the Indian Nation.

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a. *The alluvial region of the Mississippi and other large rivers.*—These lands have a dense growth, consisting of sweet-gum, water, willow, red and swamp chestnut oaks, dogwood, ash, elm, maple, hackberry, &c.

These alluvial lands constitute a nearly level plain intersected by numberless bayous. The highest lands are nearest to the water-courses, whence they slope gently towards the cypress swamp, which commonly occupies the central parts between two contiguous bayous. Where the alluvial plain is very wide, islands or low ridges of uplands, with characteristic oaks and short-leaf pine, break the monotony of the otherwise level plain. Crowley's Ridge in Arkansas may be cited as an example.

The typical bottom soil is the so-called "buckshot clay," named from the circumstance that in drying it breaks up into small fragments about the size of buckshot. This soil appears to be the sediment which forms the ancient river plain, and it is most profusely fertile.

Near the larger streams the soil is more sandy, and this sandiness decreases towards the cypress swamps, which in general have a heavy, clayey soil, somewhat like the buckshot soil, but which, from liability to overflow, are very little in cultivation.

The cultivation of these bottom lands is mostly confined to the narrow strip usually above overflow, lying contiguous to the streams, and called the *frontland.* The *backland* intervening between this and the *cypress swamp* is sometimes also in cultivation, but is rather liable to overflow.

The quality of the soils varies between wide limits, the buckshot soil representing the one extreme, while light, siliceous, silty soils represent the other.

b. *The marsh lands.*—These are usually devoid of large trees, but are occupied by rushes and sedges. They are comparatively little in cultivation and need not be further described.

2. THE LOWER PRAIRIE REGION.

Under this heading are included, besides the lower prairies of Louisiana and Texas, the savanna and prairie lands of Florida, and the *llano estacado* and gypsum lands of Texas and the Indian Nation. These latter have very little in common with the preceding except the absence or great scarcity of timber.

With the exception of the coast prairies, they are of no importance in the cultivation of cotton, and require no special notice.

a. *The central and coast prairies.*—In Louisiana these are of threefold character—black calcareous prairies, brown loam prairies, and gray silt prairies. In Texas the coast prairies are chiefly of the first sort, but in the eastern part of the State there are also some of the gray silt or pine prairies.

In these prairies the soil varies from a black, calcareous loam to a fine, light-colored silt. They are usually nearly level and devoid of trees,

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except an occasional *motte* of live-oak, and in the silt prairies a few long-leaf pines.

In fertility the soils vary greatly, the black prairie being quite fertile; the others are less so, but none are very extensively cultivated. The whole region is thinly settled.

The soils are derived from the clays and other sediments of the Port Hudson group, which also yield the soils of the alluvial region of the rivers above mentioned.

The silt prairies are usually ill-drained and little cultivated.

A strip of this kind of land lies between the Arkansas and White Rivers, in the State of Arkansas.

b. *Savannas and prairies of Florida.*—These are treeless regions, low-lying and nearly level. The prairies are clothed with a carpet of grass and make the best pasture lands; the savannas are usually covered during a great part of the year with water, and present the appearance of grassy lakes. The Florida everglades consist of a labyrinth of marshes and savannas, intersected by extensive lagoons and lakes.

None of these are of importance in cotton cultivation, except that upon some of the prairies the sea-island or long-staple cotton is produced to a limited extent.

c. *The gypsum lands and staked plain of Texas and the Indian Nation.*—The gypsum lands are slightly rolling, with red loam soils, and are almost destitute of timber. The plain is interspersed with hills in which heavy beds of red clay and gypsum appear.

The *llano estacado* and table lands of Texas are in all probability of Cretaceous age, since the Rotten limestone with its characteristic fossils appears in the deep cañons of the south. This plain is very nearly level, devoid of trees, and almost of water and grass, with some prominent sand hills or dunes along the north of the region, and also on the east of the Pecos River.

In addition to the above, the western portion of the red loam region of Arkansas, Indian Territory, and Texas, which rests upon the Carboniferous formation, assumes the characters of a prairie. See further under "Red loam region (6)."

3. THE LONG-LEAF PINE REGION.

This division occupies a belt of width varying from 75 to 150 miles, and extending from eastern Texas to Virginia along the Gulf and Atlantic coasts.

Its two most prominent subdivisions are based upon the proportions existing between the long-leaf pine and the upland oaks among the timber trees. These subdivisions are—

a. The long-leaf pine hills and flats;

b. The oak and hickory uplands with long-leaf pine;

c. The hammocks of Florida, shell prairies, lime hills, and red lime lands of Mississippi, Alabama, and Florida.

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Of these, the first occupies the region nearer the coast, the second forming a sort of transition to the oak uplands of the Paleozoic formations, while the third appears in detached bodies in the long-leaf pine region.

a. *Long-leaf pine hills and flats.*—As is indicated by the name, the long-leaf pine forms the prevailing, and in places the exclusive, timber over this whole region. It is associated with black-jack and post oaks and occasionally with the short-leaf pine, which makes its appearance wherever there is a slight improvement in the quality of the soil.

In the vicinity of the coasts the surface is nearly level, or at most gently undulating, rising northward and inland into a somewhat broken and hilly country upon which the pine is always the characteristic growth. Along the coasts the Cuban pine also is common.

The soil is mostly a very light sandy loam of little fertility or durability. The cultivated lands are generally confined to the creek bottoms and other low-lying lands, though some of the uplands, especially where there is a mixture of the upland oaks and hickories among the trees, are planted in cotton, and with success, particularly where commercial fertilizers are used.

The open pine woods support a fine growth of nutritious grasses and leguminous plants, and hence afford excellent pastures for cattle and sheep.

These open forests have very little undergrowth on the rolling lands, but a dense growth of evergreens in the marshy depressions, and along the streams.

The most common of these shrubs and trees are mentioned above, in the section treating of the forest growths.

b. *Oak and hickory uplands with long-leaf pine.*—The region in which the long-leaf pine with black-jack, post, and high-ground willow oaks form the timber is interspersed with tracts more or less extensive, in which the other species of upland oaks are associated with the pine, and this association becomes almost universal in the upper districts, and has given occasion to the recognition of this region of mixed growth as a distinct agricultural subdivision.

The surface is generally broken, and a red or yellow loam forms the top stratum of the drifted materials which, throughout the pine region, have been spread over the lower and older rocks.

The soils vary from a tolerably fertile loam of brown to reddish colors in the best uplands to a sandy light loam in the poorer spots, and their distribution may be partly explained by the following considerations:

The Paleozoic formations of the Cotton States are bordered towards the coasts with a belt of drifted materials consisting of sand, pebbles, and a red or brown loam. Of these materials the pebbles are mostly confined to the vicinity of this ancient shore line, except where they ap-

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pear to have been subsequently taken up and redeposited further down the courses of some of the principal streams.

The red loam also appears in greatest force and most characteristically along the same line, while the sands have been spread much further outward.

Where the red loam is the surface material the growth consists of the upland oaks and short-leaf pine; where the sands prevail the long-leaf pine becomes characteristic, so that, in general terms, the oak growth follows the margin of the older formations, while the pine prevails further outward toward the coasts.*

As has been said above, the red loam is usually found as the uppermost stratum of the drifted materials, and where in the drainage areas of the streams this capping of loam has been washed away so as to bring to the surface the underlying sandier strata, the natural growth gives evidence of the deterioration of the soil in the association of the long-leaf pine with the other timber, and in its complete replacement of the other trees in the sandiest localities.

These strips and patches of pine land interlace so intricately with the oak and hickory lands as to render any accurate mapping of them impossible without close and detailed surveys.

c. *Hammocks, &c.*—(1) Hammocks. In the long-leaf pine region of Florida there are patches of land in which there is a luxuriant growth of water, willow, white, live, and other oaks, hickories, sweet gums, and other hard woods. Such areas are called hammocks, and they are extremely fertile, forming amongst the very best of the cotton lands of the State. The hammocks are produced by the reaction of the limestone, which underlies the State of Florida, upon the sandy loam which forms the soil, and, according to their position, are called high hammocks, low hammocks, and Gulf hammocks, and their yield in cotton is frequently as high as a bale to the acre.

The sea island or long staple variety is almost exclusively produced upon the hammock lands, except in the red clay hammocks (as they are called) of the upper part of the State, around Tallahassee and other localities. These hammocks are, however, about the same as the mixed oak and hickory and pine lands above mentioned.

(2) Shell Prairies, Lime Hills, and Red Lime Lands of Mississippi, Alabama, and Northern Florida. The Tertiary rocks of these States in places react upon the overlying loams in such a way as to produce highly fertile calcareous lands, usually of rather limited extent, and in detached bodies among the prevailing pine lands. In some countries these form the best of the cotton lands.

* In Alabama, Georgia, South and North Carolina the hilly belt (with sand and pebbles), which borders the older formations, has occasionally a preponderance of long-leaf pine among the timber trees, though the pines are here in places associated with, and even replaced by, the oak and hickory growth of the better class of uplands.

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4. THE OAK UPLANDS REGION.

This subdivision includes some of the best cotton lands in Texas, Louisiana, Arkansas, Mississippi, and Alabama. The top soil is a brown or reddish loam which overlies the sands and pebbles of the Drift, as above mentioned, under the long-leaf pine region.

The underlying, older rocks throughout nearly the whole of this region are the Lower Tertiary beds, which are chiefly lignitic, sandy clays. In their mode of origin it will be seen that these soils are entirely similar to those of the better class of long-leaf pine uplands of the States further east. The absence of the long-leaf pine is one of the chief distinctions between the two.

In respect of fertility and general agricultural value, two subdivisions may be recognized, viz:

a. The yellow loam uplands, or oak and hickory land with short-leaf pine.

b. The table lands of Mississippi and Tennessee, and the Cane Hills or Bluff region.

a. The yellow loam region.—Under this head is included that great body of oak and hickory uplands associated with the short-leaf pine, extending from Texas to Alabama.

The face of the country is broken, except on the watersheds, as is always the case where the red loam forms the surface over beds of Stratified Drift.

The soils of the better class of these uplands are yellowish or brownish loams, varying in thickness from a few inches to as many feet, and underlaid by the sands and other beds of the Drift. On the poorer uplands the stratum of loam is very thin, sometimes almost entirely absent, and the underlying drift sands or other materials then form the soil. Between these two extremes there are all the gradations, and the different qualities of soil are so intricately interspersed as to render it impossible to lay them down with precision. The general remarks above given, under the long-leaf pine region, will apply equally well here, to show the principles which govern their relative distribution.

b. Table Lands and Cane Hills.—(1) The table lands. These occupy a strip of 20 to 30 miles width, lying adjacent to the bluff of the river in North Mississippi and across West Tennessee, and, as the name shows, form in the main a level table land, except where the streams have cut their channels. The soil is a brown loam of great fertility, and specially suited to cotton. The timber consists of oaks and hickories, and of the former the post, red, and black oaks are the most abundant. In the more clayey belts these are accompanied by the black-jack, and, on the lighter soils, by the Spanish oak.

In quality the table-land soils show a gradation into the preceding class.

The table lands of North Mississippi have long been noted for their fertility, but there is the serious objection to them that they are so

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easily injured by washes, which carry away the top soil, and frequently leave bare the rather sterile sands and other materials of the underlying Drift.

(2) The cane hills. This includes a narrow strip of lands, averaging perhaps 15 miles in width, lying immediately adjacent to the bluff of the Mississippi River, being best developed and most continuous on the eastern side of that river in Louisiana, Mississippi, and Tennessee.

The surface is generally hilly and broken, and its timber consists of water, willow, swamp chestnut oaks, hickories, beech, magnolia, locust, tulip tree, and originally a dense undergrowth of cane, which has since mostly disappeared.

The soil is a fertile brown loam, 4 to 7 feet in depth, resting on a fine calcareous silt of the Bluff or Loess formation.

There is in this region also a great liability to injury from washes, and many farms have thus been ruined.

5. THE UPPER PRAIRIE REGION.

This region has been subdivided into two, viz:

a. The black prairie lands, and

b. The blue marl lands and hill prairies.

Within the area herein included there are many varieties of soil, from the poorest sandy ridges to the richest black calcareous loams, and the names have been chosen which apply to the most characteristic soil varieties.

a. Black prairie lands.—East of the Mississippi this region is comprised in a belt extending from the eastern edge of Alabama, nearly westward through that State, and northwest through Mississippi, and north through Tennessee. In Alabama the width of the belt is 20 to 30 miles, but in Tennessee it narrows down considerably. This region occupies a depression between hilly lands with oaks and pines, and its surface is comparatively level, with here and there small hills and ridges capped with sand and loam, the remnants of a covering of Drift which probably once covered the entire region, but which has subsequently been almost entirely removed by denudation.

The underlying rock throughout the whole region is an impure limestone (Rotten Limestone), the disintegration of which has given rise to the peculiar soils of this region.

The typical black prairie soil is a stiff calcareous clay of grayish to yellowish color when uncultivated, but of dark to nearly black color when mixed with vegetable matter in cultivation.

In the vicinity of the ridges and hills of Drift above alluded to, the sands and loam of this latter formation are more or less mingled with the calcareous clays, and there result mixed soils of varying degrees of fertility and of different physical qualities. One of these mixed soils is known as the post-oak soil. It is a stiff loam of reddish to yellow color supporting a growth in which the post oak is prominent.

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Upon the ridges are the usual upland soils similar to those of the oak uplands elsewhere.

The original growth upon the black prairie lands consisted of oaks, poplar, beech, &c., of magnificent proportions, but very little of this growth now remains standing.

In Alabama this is known as the "Canebrake," and the "Black Belt," and the "Cotton Belt," from the facts that a dense undergrowth of cane once covered the land, and that it is pre-eminently the cotton-producing region of the State. This may be seen from the percentage map accompanying this article.

West of the Mississippi River this division has an extensive development in Texas, where its soils are black, wax-like clays, similar to those already described, and derived from the Rotten Limestone. In these, beds of Drift are nowhere to be seen except in the "Cross Timbers." (Loughridge.)

The Cross Timbers thus appear to be the analogues of the Drift ridges which traverse the prairie region in the eastern States of the cotton region.

In the Indian Nation black prairie lands entirely similar to those of Texas are seen in the southern portion, coming to an end near the line of Arkansas.

In the latter State small areas of black Cretaceous prairies occupy the lowlands in the southwest, while the ridges between the streams and between the prairie tracts are short-leaf pine uplands, with oak and hickory.

A characteristic growth of the northeastern part of this great western Cretaceous belt, in Texas, Arkansas, and the Indian Nation, is the Bois d'Arc, or Osage Orange. In the States east of the Mississippi River the patches of open, treeless prairie are of less superficial extent than the wooded tracts.

As in the States east of the Mississippi, the western lands of this character are largely cultivated in cotton.

b. *Blue marl lands and hill prairies.*—In Mississippi and Alabama the southern and western borders of the prairie lands are frequently made by a hard, yellowish limestone which gives rise to a broken and ridgy country, the summits of the ridges possessing soils of the usual sandy upland type, while the hillsides and lowlands, by the reaction of the decaying limestone on the loams, have often stiff clayey soils, much like those of the post-oak prairies.

From their position and topography these are known as hill prairies. Limited areas with loamy soils of deep red color, and full of pebbles of brown iron ore, occur along this outer margin of the Cretaceous belt both in Mississippi and in Alabama.

Still another type of soils prevails in a few places in Mississippi and in the eastern portion of the Cretaceous belt in Alabama. These are

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the blue marl lands, derived from a blue marl which lies near the top of the Cretaceous series.

The timber upon these blue marl lands is a curious mixture of gums, bottom oaks, and long-leaf pines, all draped with the long moss. A large body of this kind of land is met with in eastern Alabama, where it is well known for the fine cotton crops which it produces.

6. THE RED AND BROWN LOAM REGION,

(Based on the older limestone formations.)

These lands are of two kinds, viz:

a. The red and brown calcareous loams, occurring east of the Mississippi River, in the basin of Tennessee, and in the valleys of East Tennessee, northwestern Georgia, and northeastern Alabama, and derived from the limestones of the Silurian and Subcarboniferous formations; and

b. The red loam uplands and prairies of Arkansas and the Indian Nation, based upon the red shales of the Coal-measures, and the red loam lands of Texas, which are derived from red sandstones and clays, partly of Triassic age and partly of undetermined age.

a. *Red and brown loam lands east of the Mississippi.*—(1) The Basin of Middle Tennessee is an elliptical basin of some 5,000 square miles area, underlaid by the limestones of the Lower Silurian age. The surface of the basin is moderately undulating, or rolling; it was once heavily timbered with oaks, walnuts, hickories, &c., which have been in great measure removed and the land brought under cultivation.

The occurrence of cedar glades is a characteristic surface feature of the basin. These are rocky places, generally flat, and more or less covered with red cedar. (Safford.)

The soils of this basin are derived from the disintegration of limestones of different grades of purity, and hence vary considerably in quality. The two principal varieties are those derived from the Trenton, and from the Nashville or Hudson River formations, respectively. The former are, as a rule, more clayey, the latter more siliceous.

These lands are fertile and well adapted to the cultivation of corn, cotton, tobacco, &c. As will be seen from the percentage map, a large proportion of this area is devoted to cotton.

(2) The Valley of East Tennessee, and its continuation through Northwest Georgia into the Coosa Valley of Alabama, is a complex trough composed of a number of subordinated valleys separated by ridges, having, like the valleys, a general northeast and southwest direction. The soils of these valleys, as they are derived from the rocks of several different formations, vary considerably. The one extreme is a stiff clayey loam of deep red color, found in greatest abundance along the southeastern edge of the valley. This is the best of the soils.

On the other extreme are light sandy loams of grayish to buff colors.

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The ridges which divide the complex trough are composed of the chert of the limestones, and have siliceous soils, and are therefore more particularly spoken of under the next head. In the narrow anticlinal valleys which run parallel to the Coosa Valley, in Alabama, the brown and red loam soils are of the same character as those just mentioned. Along the edges of these valleys, on each side, there is usually a narrow strip with yellowish loamy soil based upon the limestones of the Subcarboniferous formation. These belts are generally in cultivation, and yield good crops when properly cultivated.

In Alabama the Coosa Valley is largely planted in cotton, but in Tennessee its continuation (Valley of East Tennessee) is devoted less to cotton and more to grain crops.

These valley lands are not level, but are rolling and ridgy, and the timber growth upon them is quite varied.

On some of the rich red lands large white, red, and Spanish oaks, hickories, sweet and sour gums prevail.

Along the flinty ridges and at their bases where the soils are more sandy and less fertile, post and black-jack oaks and short-leaf pine become characteristic, and in some portions of Alabama the long-leaf pine is of constant occurrence, not only on the ridges, but also on the rolling lands underlaid by the siliceous limestones. Such is particularly the case in the vicinity of the Coosa River.

(3) Tennessee Valley in North Alabama. This division, like the Basin of Tennessee, rests on limestones, which, however, belong to the Subcarboniferous formation. The surface is slightly undulating, with low, rocky knolls timbered with post and other oaks, the remnants of a once universal forest of oaks and hickories. The greater part of this valley is cleared and under cultivation, the exceptions being the flinty, rocky knolls above mentioned, and glady places covered with red cedar.

The prevailing soil is a rather stiff loam of red to brown color, and it is highly fertile in its virgin state.

Notwithstanding the high latitude of the Tennessee Valley, a large percentage of its area is devoted to the culture of cotton, as may be seen from the map.

b. *Red loam lands west of the Mississippi.*—(1) Red loam uplands and prairies of Arkansas. These lands, as already stated, are based upon the shales of the Coal-measures. The uplands are rolling or hilly, and are timbered with a fine growth of red, scarlet, black, yellow, chestnut, and laurel oaks, sweet and black gums, wild cherry, shell-bark hickory, and other species. (Lesquereux.)

The red upland soils are considered the most fertile of those occurring in the western part of the State. Where the land is level or flat, prairies are found, which, when the soil is close and clayey, are badly drained and marshy and not in cultivation, though they make excellent

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pastures. In some cases where the soil is looser these prairies are to a slight extent cultivated and produce excellent crops.

Through the region of the red uplands run ridges of sandstone, the soils of which are best considered under the next head.

The red loam lands pass through the Indian Nation also, where they present substantially the same features as in Arkansas.

(2) In Texas the red loam prairies and timbers overlie the older formations almost entirely; the timbered hills on the eastern part are capped with what are supposed to be Triassic sandstones. (Loughridge.) The timber on these hills is mostly post oak and black-jack. The valleys are largely prairie, with mesquite timber growth, and with soils varying from a red sandy loam on the uplands to a darker loam on the flats, sometimes quite clayey. The western part of this region is prairie, with red loam soils, derived presumably from the red clays that appear in the bluffs and hillsides of this and the gypsum region. Their geological age is undetermined. (Loughridge.)

7. THE SANDY AND SILICEOUS LANDS OF THE OLDER FORMATIONS.

These comprise—

a. The cherty lands derived from the impure siliceous limestones of the Subcarboniferous and Silurian formations;

b. The sandy, sometimes loamy, soils resting upon the rocks of the Coal-measures, especially in the States east of the Mississippi River; and

c. The sandy prairie lands of the Indian Territory, which also rest upon the sandstones of the Coal-measures.

a. *Cherty lands.*—In East Tennessee, Northwest Georgia, and Northeast Alabama the cherty limestones of the Lower Silurian and Subcarboniferous formations, in their decay, give rise to soils which may be described as light, rather sandy loams, of yellowish or buff colors, and which are usually filled with angular fragments of the chert. In this region the strata are, as a rule, thrown into folds, and the soils in question are found in narrow strips or ribbons, which have the prevailing direction of northeast and southwest. On account of the comparatively indestructible nature of the materials (siliceous limestones) from which the soils are derived, they are also commonly found in ridges, the valleys between being occupied by the red and brown loams of the limestones mentioned in the preceding section.

In fertility these ridge soils vary greatly. Notwithstanding the unpromising appearance of the soil, because of the rocks which fill it, it is often of considerable fertility, and usually supports a fine growth of white, black, red, black-jack, and post oaks, hickories, and short-leaf pines, the latter making their appearance where the soil is more sandy. The growth on the cherty ridges of both Silurian and Subcarboniferous formations seems to be substantially the same, except that in some localities the ridges of the former appear to be more sterile and have a

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larger proportion of pines; and in some parts of the Coosa Valley, in Alabama, they are occasionally timbered with long-leaf pines and black-jack oaks almost exclusively.

In the Valley of the Tennessee, in North Alabama, and around the margin of the limestone basin of Middle Tennessee, the cherty Subcarboniferous limestones lie nearly horizontal, and they thus come to be the substratum of wide areas, which in these States are known as "*barrens*," from the comparative infertility of the soil, as compared with that of the adjoining limestone lands. These barren soils are usually thin and deficient in lime, and have a high percentage of siliceous matter.

The timber consists of oaks, often shrubby and stunted, small hickories, dogwood, &c., in the lower latitudes, mixed with short-leaf pines. The oaks are of several species, but the post oak and black-jack appear to be the most common.

These lands are very sparingly cultivated in cotton, and hence need no special mention beyond what has been given.

In their topography, the barrens are in contrast to the red loam lands which are adjacent to them. The hard, flinty, indestructible chert is worn into rough, precipitous hills wherever the somewhat level watersheds break off towards the streams.

West of the Mississippi, the same formations produce similar soils and topography in northern Arkansas, where the cherty ridges are clothed chiefly with mockernut hickory and post and black-jack oaks. With these are associated, in those localities where the soil is more sandy, the yellow or short-leaf pine (*P. tæda*). Along the declivities appear the white, red, and black oaks. Upon these formations in northern Arkansas also occur prairies of limited extent, surrounded with a growth of small trees. These prairies, which are not always of flat surface, are found along the gentle slopes or in the coves between the ridges.

The bottom lands derived from these cherty limestones are generally highly productive.

b. *Sandstone soils.*—The other class of siliceous soils is derived from the sandstones and grits of the Coal-measures. In general they are of only medium fertility, and are of comparatively little importance in the cultivation of cotton. Lately, however, in some of the eastern Cotton States, it has been found that with the use of commercial fertilizers very fair cotton crops may be produced upon these soils, which have in general a subsoil of yellowish loam, which is moderately impervious and holds well the fertilizers that may be applied to the land.

In Alabama and East Tennessee a large area is underlaid by the Coal-measures, and the table lands or plateaus of a part of this area are admirably situated and will doubtless some day be more generally cultivated than is now the case.

The best of these soils are light-colored loams, with yellowish or reddish subsoils. These are capable of improvement and successful culture. The gray soils with light-colored to whitish subsoils, deficient in

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clayey matter, are too porous for profitable cultivation, and do not retain the fertilizers that may be applied to them.

The greater part of the soils of the Coal-measures are sandy and rather deficient in vegetable matter and in lime. In topography this region is varied. On the table lands of Tennessee and North Alabama the surface is slightly rolling, sloping off gradually to the water-courses. In the upturned fields of the Coosa, Cahaba, and part of the Warrior Basins in Alabama, the alternation of harder and softer strata gives rise to some of the most rugged topography to be seen in the State.

The timber consists chiefly of the upland oaks, and, in some of the lower latitudes, short-leaf pine. In some parts of Alabama areas of considerable extent with a prevailing timber of long-leaf pine are known.

In Arkansas, it has already been seen that the chief soil of the Coal-measures is a red loam derived from the shales, but the red uplands are traversed by ridges capped with sandstones, or millstone grit. The soils on these ridges are thin and generally sterile; except, where the ridges are broad, the soil becomes thick and is tolerably fertile. The characteristic growth here is much the same as that on the cherty ridges of the Subcarboniferous formation above described, viz., yellow pine, Spanish, post, black-jack, white, red, and black oaks, hickory, chestnut, and chinquapin.

Agriculturally this soil is inferior to that of the red loam uplands.

c. *Sandy prairies.*—In the Indian Territory, the Carboniferous is mostly a prairie region, interspersed with prominent ridges of the sandstone. The soil is a sandy loam, brownish in color and not very durable or fertile. Along the rivers are timbered belts of quaternary sands, sometimes very deep, underlaid by reddish clays and furnishing some good lands. The river bottoms are the chief cultivable land. (Loughridge.)

8. THE GNEISSIC REGION.

The metamorphic region of the Cotton States is comprised in a belt sometimes 150 miles in width, extending from central Alabama northeastward through Georgia, South Carolina, and North Carolina into Virginia. By far the greater part of the cultivated soils of this region is derived from gneissic rocks—under which name we include not only the gneiss itself, but the kindred rocks, not excepting granite, with which the gneiss is connected by all gradations.

This metamorphic area includes most of the really mountainous region of the Cotton States, but the southeastern slopes of the mountain ranges are undulating and hilly rather than mountainous. The mountain ranges are composed of quartzites, mica schists, and other indestructible rocks, while the gneissic rocks are more prevalent along the southeastern border, which is also the part of this area that is to any considerable extent in cultivation. Among the mountains the farms are small, and cotton forms a small proportion only of the cultivated crop.

The typical gneissic soil is a gray soil of considerable fertility, whose

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natural timber consists of the upland oaks with some short-leaf pine; along the borders of the region the long-leaf pine also makes its appearance wherever the sandiness of the soil increases beyond a certain limit.

The true gneissic soils are perhaps the best for cotton.

By gradual interchange of constituents, the gneisses grade off into the other rocks of this series, and a corresponding variation in the quality of the soils is thus brought about.

By the partial or complete replacement by the mineral hornblende of certain of the constituents of the gneiss are produced the hornblendic gneisses and hornblendic slates, which, in disintegrating, yield those warm, red, loamy soils, with timber of magnificent oaks, making perhaps a fourth or less of the lands along the outer border of the region.

The red soils are considered best suited to the grain crops, though they give fine yields of cotton also.

All the gneissic soils have a reddish, clayey subsoil, and are capable of indefinite improvement.

Through Georgia and South Carolina the gneissic soils form by far the larger proportion of the lands cultivated in cotton, as may be seen from the percentage map accompanying.

The clay slates, mica slates, and quartzites of the metamorphic region yield soils of inferior fertility, and they are of comparatively little importance in the cultivation of cotton.

West of the Mississippi the metamorphic areas are of somewhat limited extent, and are comparatively unimportant from our standpoint.

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CHAPTER VII.

TERRESTRIAL AND METEOROLOGICAL INFLUENCES AFFECTING THE WORM.

CONDITION OF SOIL AND PLANT CONNECTED WITH THE APPEARANCE OF THE FIRST WORMS.

Having seen that the worms first appear in parts of the southern portion of the cotton belt at a much earlier date than previously supposed, we will now briefly consider the conditions of soil and of the plant connected with this first appearance. In glancing over the reports on this subject in answer to our questions, we find a remarkable unanimity of opinion corresponding with what has been observed by ourself and assistants and with the general experience collected. It is that the earliest worms of the season are confined to fields on the "low lands" where the plants are naturally more thrifty and more advanced than on any other soil. Low lands where cotton is planted in Texas and Louisiana comprise the so-called bottom lands of the rivers, and on such lands the soil is always a very rich alluvium and never sandy. Farther east, however, low lands are frequently sandy and the bottom formation of alluvial soil is less common than in Texas and Louisiana. This holds especially true of Florida, where the soil is exclusively sandy, more or less mixed with decayed vegetable matter. In the latter State fields on "hummock land," and near the edges of ponds or lakes replace the bottom lands of Texas and Louisiana. The rule of the first appearance on such low, rich, and moist lands does not apply alone to the extensive area of such land in the southern portion of the belt, but also to similar low places in particular parts of plantations in the whole cotton-growing country, the first worms on any plantation always being noticeable in such low spots.

The general rule, however, is not without exception, for on the sea islands off the coast of Georgia and South Carolina, where, in former years, the worms always appeared early, the soil in which cotton was and is, to a limited extent, still cultivated, cannot be called low land. All low parts on these islands are occupied by marshes, and are unfit for cultivation, and the soil of the cotton fields is what is termed "dry hummock land." Again, Mr. Schwarz found a very early appearance in Lavaca County, in Southern Texas, where the country is several hundred feet above the river bottoms in the same latitude, and consists of open and

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rolling prairies. The worms were observed there in a field situated on top of one of the highest hills, and they have been observed there at similarly early dates in past years. The soil is, however, of that rich, black nature peculiar to one part of the South Texan prairies.

A second circumstance which, according to the unanimous reports of planters and observers, appears to necessarily accompany the early appearance of the worms, is that the cotton plants must be in a well-advanced and luxuriant condition. The earliest worms are never known to appear in fields in which the growth of the plants has been retarded from one cause or another, as, for instance, late planting, the attacks of plant-lice, overflow, poor, exhausted, or sandy soil, &c.

A third fact is worthy of mention in connection with this early appearance, viz., that in open countries, or in countries where the prevailing soil is low and rich, there is almost always a gin-house or other building, a hay-stack or some other shelter near by where the moths have, to all appearance, hibernated. Of the five localities in South Texas where the first worms were observed by Mr. Schwarz in the spring of 1879, three were in the immediate vicinity of gin-houses, with no other building, fence, or tree in the neighborhood. In the fourth a gin-house and other buildings, as well as trees, were close by; while in the fifth (that in Lavaca County, already mentioned) the nearest object which could have served for the hibernation of the parent moth was an open stable about one hundred yards distant, but covered with a thick thatch of hay.

In all cases observed or reported, the first worms occupy but a limited patch in the field, and are not scattered over the whole field or over large portions of a plantation, as is the case with subsequent generations. The extent of this patch seldom exceeds two acres and sometimes does not embrace one-fifth of an acre.

Still a fourth circumstance connected with the appearance of the first worms is noticeable, and one that, as we shall see farther on, has much importance from the practical side. It is that they recur year after year, not only in the same counties, but also in exactly the same spots.

The condition of the plant has already been alluded to. In every case it was luxuriant, advanced, and vigorous. This condition of the plant has so much to do with the matter under consideration that there must be a cause for it, whether in the greater attraction for the moth possessed by such plants or the greater facility with which the eggs hatch or the worms develop upon the same; for when produced artificially by the use of manures and good cultivation, it may, and often does, have the same effect, and counteracts the otherwise unfavorable condition of soil and location.

As throwing light on the subject, and as a rational explanation of the facts, it is well to remember that the most advanced and luxuriant plants most copiously exude from the secretory glands the sweet fluid upon which the moths feed and by which, it is fair to presume, they are attracted; also that the moths' fondness for shade and moisture is grati-

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fied in such low places where the cotton is rank. These places are also just those where the dews are heaviest, and the facts which follow render it quite certain that moisture aids both the hatching and the development of the worm. Another suggestion may here be made that also helps in the explanation; the natural enemies of the worm, especially the ants, are less abundant in low, wet land than in that which is higher and drier. They will, therefore, be less efficient in destroying the young worms, which for this reason will stand a better chance of developing unchecked.

INFLUENCE OF WET WEATHER.

In the foregoing pages we have seen that the insect, both in its larva and perfect states, has a predilection for low, moist ground, where the cotton is luxuriant. We may safely infer, therefore, that the meteorological influences that produce over large areas the conditions thus described for limited areas will prove favorable to the development of the worms; and, indeed, it is the uniform testimony and experience of all who have closely observed the facts that wet weather is favorable and dry weather unfavorable thereto. This appears not only from the testimony of observers and of correspondents of the Department and of the Commission in this country, but also seems to be the case in South America. The United States consul at Pernambuco, for instance, says "it comes and disappears with the rain." A study of the past history also reveals the same fact, and in no instance more strikingly than in the consideration of the year 1873. As indicating this in a most forcible way we introduce again the tabulated statement of correspondents of the Department showing the relative influence of each cause of damage. Rain and worms go hand in hand.

North Carolina.—Rains, frost, worms.
South Carolina.—Rains, frost, worms.
Georgia.—Worms, more than all other causes combined; rains, frost, drought, high winds.
Florida.—Storms of rain, worms.
Alabama.—Worms, rains, frost.
Mississippi.—Worms, spring rains, drought, frost.
Louisiana.—Worms, rains, high winds.
Texas.—Worms, rains, drought, frost, bad gins and inexperienced ginners.
Arkansas.—Rains, worms, drought, frost.
Tennessee.—Drought, frost, rains, plant-lice, a cold and wet spring.

We have not to deal here with those severe rains, especially those accompanied by gales of wind, such as occur occasionally in the South, especially during the autumnal equinox, which have been known to kill the worms, beating them down and sweeping them into windrows and heaps, such as was the case in Mississippi in 1825; in Matagorda County, Texas, in September, 1875, and in the Bahamas in 1866; for in these and similar cases the destruction of the worm is always accompanied by the utter loss of the crop.

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Nor have we to deal with the cold rains that characterize the Southern winter, and sometimes occur as late as the beginning of May. The influence of this weather on the hibernating moth has not been definitely ascertained, but it is more than probable that, when occurring late in spring, especially if accompanied by a "norther," it may prove as injurious to the first generation of worms as it is known to be to the cotton-plant. We have to deal rather with that broiling and humid state of the atmosphere consequent upon frequent showers and a clouded sky during the summer months or later. The earth may be said to steam, and the air is full of vapor. The influence of such weather is twofold, viz., direct and indirect.

Its direct influences may, perhaps, best be illustrated by citing, in contrast, the effects of dry weather, which effects we have repeatedly had excellent opportunities of watching and studying. As witnessed in the field, a large portion of the eggs during dry weather actually desiccate and fail to hatch. The worms are less active, and wanting in vitality; they drop more easily to the ground, and are so affected by the dry, heated surface that, in almost every instance, they fail to regain the plant. While vigor and vitality are thus impaired, the development during such weather is unduly hastened. The worms, for the most part, web up prematurely and fail to effect the change to chrysalis, generally dying in the act, half-worm, half-chrysalis. The chrysalides, in case the transformation was successful, show a great tendency to rot, while the moths, which hatch from the comparatively few that remain sound, find scarcely any food in the cotton field, as the glands, already described (p. 10), are almost entirely wanting in honey during very dry weather. Nourishment and fecundity being correlated, it is more than probable that the moths, poorly nourished, will lay fewer eggs under such circumstances. All the effects described are intensified and become most marked during extreme drought, so that frequently at the end of a dry spell, such as is not infrequent in July and early August, not a worm can be found. A rainy season, following such a spell, will produce a most noticeable change. Its effects are almost magical. The plants freshen up, and the moths simultaneously become active; their eggs hatch freely, and the worms are so voracious and active that they soon destroy the new leaves or "top crop" and then, of necessity, work on the older ones.

The effects of dryness, as here described, are equally noticeable when produced artificially. Experiments upon plants growing in the field, but inclosed in muslin-covered frames, have produced all the unhealthy conditions of the insect, simply because the covering prevented the normal precipitations of dew upon the plants; while in vivaria the injurious effects of a dry atmosphere have been equally noticeable. In the dry, hot air of the Bahamas the worms are reported as often dying from the heat in numbers on the plant; a fact which would indicate that our climate is more favorable to their welfare than that of those islands;

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for the worms seldom, if ever, die from excessive heat in this country, except as they fall upon the heated surface of the ground.

The indirect influences of wet weather, first pointed out by the writer in July, 1879, in some remarks before the Mobile Cotton Exchange,* are even more potent in favoring the development of the worms. They consist in the comparative immunity which the pest enjoys during such weather from its numerous natural enemies, presently to be mentioned, all of which are prevented during wet weather from working with the energy and activity they display during dry weather. This holds especially true of birds and ants, the latter of which not only hie to their nests during such weather, but are often drowned in countless numbers in open fields during heavy showers. Few who have not carefully observed the facts can appreciate the results of the non-working, even for a few short days, of these natural checks to a species so remarkably prolific and quick of growth as our Aletia.[24]

It may also be remarked in this connection that wet weather is unfavorable to the poisoning of the worms, and prevents the working of cotton, which working, as will be shown further on, also helps to destroy them.

Such are our conclusions and the reasons therefor. One of our correspondents has, however, made the statement that in his locality a dry season *may* be followed by worms, while a wet season may not; and he is inclined to lay great stress upon the effects of east and southeast winds in bringing the worms. We quote herewith one of his letters which we formerly published in the *American Entomologist*, Vol. III, pp. 105–106 (April, 1880):

INFLUENCE OF WINDS ON ALETIA.—I discover your leaning towards the theory that in this latitude the Aletia hibernates, and that the advent of it on the summer's cotton growth is from the hibernated moth of the vicinage.

I have heretofore expressed both to yourself and to Professor Comstock the result of my observations, to the effect that a dry season—that is, one not too wet for cotton—may be followed by the caterpillar, in this latitude, in such numbers as to do great injury to the crop; and that a wet season—that is, one in which the rainfall lessens the maturity of the fruit—may not be followed by the caterpillar in sufficient numbers to injure the crop.

I desire to direct afresh your observation to the *influence of the winds* on the Aletia. For some years past this has been my own observation on that subject, viz:

(1) At *any season of the year* the prevalence of southeast winds for two or three days consecutively, regardless of *wet* or *dry* weather, will be followed in fifteen to twenty days after the prevalence stated of those winds by the moth of the Aletia in large numbers.

(2) If the winds prevail from any other course than east and south of east, after May and until October, we do not, in this latitude, find the caterpillar in numbers sufficient to injure the crop of cotton.

(3) Last year (1879) I made note of the following facts: The month of May was dry in this vicinity; so dry that corn was retarded in growth, and everywhere unpromising; *east and southeast winds prevailed; ergo* (?) early in June the cotton caterpillar was reported in large numbers in Montgomery and Dallas Counties!

* Mobile Register, July 9, 1879.

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(4) Early in June the winds changed their course from east and southeast to south and southwest. The caterpillars present did no harm whatever for full three months.

Now, let us note the seasons from June to 10th September, when, at this latter date, the caterpillars began to destroy the crops.

The season from June to 15th July was dry, and the winds south and southwest.

A rainy season began on the 15th July. We had daily rains until 19th August. The winds continued to come from south and southwest all the rainy season. The caterpillars did *no harm* in this rainy season, although they were alarmingly present.

The rain ceased 6 days to begin again on the 25th August.

The winds veered on the 25th August, or about that day, from south and southwest to east and southeast, and by 10th September all *the foliage had been* stripped from the cotton.

The summary of these facts is that (1) early in June after a dry May, distinguished by the prevalence of east and southeast winds, the caterpillar appeared; (2) the caterpillar did not then eat the crop, and contemporaneously with its advent the winds changed from east and southeast to south and southwest; (3) a rainy season put in 15th July and was excessive until 19th August, and the winds were south and southwest, and the caterpillar though present did no work; (4) the rains began again 25th August and the winds were then, for *the first time since May, east and southeast*, and by 10th September the caterpillar had destroyed the crop.

There were two seasons of east and southeast winds *only*, one in May followed by the caterpillar, another from 25th August to 10th September followed by the caterpillar.

The caterpillar was present from June until 25th August, but did no work, and in that time the winds were south and southwest.

What effect has the course of the winds on the character of the growth of the cotton plant? and what character of growth in the cotton plant is favorable or unfavorable to the sustenance of the caterpillar?

My observation is, the prevalence of east and southeast winds is followed by a rich, juicy, sappy, heavy foliage, never that which precedes a heavy *fruitage* of *blooms and bolls;* and that the prevalence of south and southwest winds is followed by small, pale-green, sharp-pointed foliage, favorable to heavy fruitage of blooms and bolls.

I have also noted that the caterpillar destroys the rich foliage much more greedily than he does the hard pale-green foliage.

It is a common remark that a "worm year is never a cotton year, even if the worm did not destroy the crop."

I never saw a good yield of blooms and bolls with the winds from east and southeast.—J. W. DuBose, *Pike Road, Montgomery County, Alabama.*

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CHAPTER VIII.

NATURAL ENEMIES.

We have already seen that meteorological conditions may favor or retard the multiplication of the Cotton Worm, but that their influence is, in a great degree, indirect, *i. e.*, by favoring or retarding the work of the insect's natural enemies. Careful observations in the field for a single season will convince any one that these natural enemies are far more numerous than has hitherto been supposed, and that without their aid man would be powerless in his efforts to cope with an insect with such powers of multiplication as Aletia possesses. Those who have carefully watched the worms in any given spot have been struck with the sudden disappearance from day to day of a certain proportion of them. This apparently mysterious disappearance is admirably set forth in the experiments made by Professor Willet with the yeast fungus, and quoted farther on. It frequently puzzled and baffled Mr. Schwarz in his efforts to watch the worms on certain special plants, and there can be no doubt that it is due mainly, if not entirely, to the efficient work of natural enemies, especially those that are nocturnal.

Since the introduction and general use of arsenical poisons as a remedy for the Cotton Worm, the economic importance of its natural enemies has greatly lessened; as many of these, especially such as bodily devour their victims, are likewise poisoned. Yet whole crops are occasionally saved by these friends to the planter, as is proven by instances given farther on. But few new enemies have been added to those treated of in the first edition of this work; but the habits of many, especially of the parasites, have been more carefully studied.

VERTEBRATES.

Among quadrupeds the Cotton Worm has few enemies of importance. Hogs are rather fond of it, as attested by many planters.[25] The Raccoon is also reported to have been seen eating the worms from the plants, and breaking these down in doing so. The Skunk and the Opossum have also been known to feed upon it. These animals can do little good, except where the worms are in such large numbers that they travel over the ground and from field to field. Bats devour large numbers of the moths, and, in favorable localities, may be seen at evening time dashing over the cotton fields in pursuit of them.

Birds are of incalculable benefit, and it is probable that most of the insectivorous birds which prevail in the South feed at times on the spe-

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cies, either in its larva, chrysalis, or moth state, but only those which have been observed to do so will here be mentioned.[26]

All domestic birds, as turkeys, chickens, guinea fowl, and geese, are fond of the worms, and may be employed with benefit. Turkeys are the most efficient, but they get demoralized when locusts or grasshoppers are abundant, by running after these, which they greatly prefer to the worms. Prairie chickens and quails often do good work in devouring the worms, while a Thrush (probably *Harporhynchus rufus* L.), the Rain Crow or Cuckoo (*Coccygus americanus* Bon.), Bluebird (*Sialia sialis*), Cardinal Grosbeak (*Cardinalis virginianus* Bon.), Mocking-bird (*Mimus polyglottus* L.), Blue jay (*Cyanurus cristatus* Sw.), Red-wing blackbird (*Agelæus phœniceus* Vieill.), Rice bird (*Dolichonyx oryzivorus* L.), and Killdeer plover (*Ægialitis vocifera*), are more or less persistent in feeding upon them. The domestic birds and some of the wild species may be attracted to a field by scattering a little corn or other grain on the ground. The most effective help to man is rendered by the gregarious species such as the Rice birds and Blackbirds, and they have protected and saved fields near their favorite resorts or resting-places. The Rice birds occur in large swarms only in the vicinity of swamps; the Blackbirds are more generally distributed, but unfortunately they nearly all migrate northward in June from those localities which are most exposed to the attacks of the worms, and they seldom return again till after frost. It is quite amusing to watch how deftly they will extract the chrysalis from its leafy or silken covering. Mr. Hubbard, while at Centerville, Fla., found that the worms had appeared in great numbers in a bottom of a quarter-acre patch of cotton on the plantation of a neighbor. On Saturday this was being rapidly eaten out, but on the following Monday not a worm could be found, and the cotton was left *in statu quo*. On Saturday and Sunday large flocks of Blackbirds had been seen in the neighborhood, and these were presumed to have devoured the caterpillars.

We may also mention the following additional species as among those which have been observed to destroy the worms: The Bee-martin or Kingbird (*Tyrannus carolinensis*, Baird), the Indigo bird (*Cyanospiza cyanea*, Baird), the Nonpareil (*Cyanospiza ciris*, Linn.), the Orioles (*Icterus*), the Barn swallow (*Hirundo horreorum*, Bart.), the Loggerhead or Southern shrike (*Collyrio ludovicianus*, Baird), the Sparrows (*Spizella*), the Wild turkey (*Meleagris gallopavo* var. *gallopavo*), the Quail (*Ortyx virginianus* Bonap.), Partridge (*Bonasa umbellus* var. *umbellus* Stephens), the Prairie chicken (*Cupidonia cupido* var. *cupido* Baird). Of nocturnal birds, several, and among them the Night-hawks (*Chordeiles*), are supposed to feed on the moths, but the proof is necessarily difficult to obtain except by shooting and examination of their stomachs, and I cannot find that this has been done.

The introduction of the English Sparrow has been recommended by several writers. The experience so far had with it would indicate that

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little good is to be expected in this direction. A number were obtained from New York and let loose in 1870 at Macon Station, Ala., but did not colonize, while in Texas they seem unable to endure the intense summer heat, for, while they are found below latitude 30° in winter, they migrate north during the hotter months, or just when they would be most useful in the cotton field. It must also be borne in mind that this bird, except during the breeding season, is more graminivorous than insectivorous. The almost universal opinion of naturalists is that the introduction of this sparrow was a great mistake, and that its spread should be prevented by every possible means.[27]

The little tree frogs (genus *Hyla*) are very often met with on the cotton plants in certain parts of the cotton belt, and they doubtless take their share of the worms. The Green Lizard (*Anolis principalis*) is also frequently to be found upon the plants, while the Ground Lizard (*Oligosoma laterale*) occurs in the fields and eats caterpillars with avidity.

INVERTEBRATES.

These consist principally of Hexapods or true insects. The spiders (*Arachnida*), however, furnish a number of species which prey upon the worms. The following species have been collected upon the cotton plant: *Oxyopes viridans* Hentz,[28] *Theridula sphærula* Em., *Euryopis funebris* Em., *Attus fasciatus* Hentz, *Epeira stellata* Hentz, *Linyphia communis* Hentz, *Tetragnatha extensa* Walk., *Xysticus quadrilineatus* Keyserling, *Mesumena georgiana* Keys., and *Argiope fasciata* (Hz.).

The first-mentioned species is widely distributed and nests on cotton, although usually it is not very abundant. The notion prevailing in some parts of the country that this spider is confined to the cotton plant is incorrect, as the species is also found abundantly upon weeds, especially in moist places. Mr. Hubbard has found it common upon cotton in Florida, and has seen it eating bees, leaf-hoppers, and other insects, but it never seemed to take the slightest notice of Cotton Worms, and remained for hours upon the same leaf with a worm without showing the least inclination to molest it. Mr. Schwarz, however, has seen it feeding upon the worms both in Texas and in Alabama.

PREDACEOUS INSECTS.

Of true insects which, from their well-known carnivorous propensities, might with safety be placed among the natural enemies of the Cotton Worm, there are a very great many, especially among the Coleoptera and Heteroptera; but we shall refer only to those which have been actually observed to feed upon them; and then note some of the species commonly found in the cotton field, and which presumably have the same habit.

HYMENOPTERA: WASPS, ANTS, ETC.—In this Order none are of greater importance than the ants. A careful observer, while going through any cotton field the latter part of summer, has no difficulty in observing the

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ants occupied in destroying the eggs of Aletia, or still more frequently in attacking the young worms that are helpless while in the act of molting, or in devouring the interior of the still more helpless chrysalides. Even old worms which, from cause whatsoever, once get to the ground, are almost sure to fall a prey to these persistent and voracious little animals; the writhings, jerkings, and jumpings of the worm being of no avail against the constantly increasing numbers of the enemy that come to the attack. Attractive as is the honey from the glands of the cotton plant to the Cotton Moth, it seems to attract few other insects, and even the ants, that have such a predilection for sweets, are only occasionally found partaking of it. The universal presence of ants on the cotton plants, and of their nests in the ground at the base of the plants, seems largely due to the similarly universal presence of the cotton plant-lice.

The ants are always to be seen busily occupied in obtaining sweets from these Aphides, while but few are noticed to be sucking the liquid secreted by the glands. Now the plant-lice rapidly decrease in number with the advance of hot weather, though they never disappear entirely from the plants. The ants, as summer advances, are thus deprived of a large portion of their principal food supply, and as their colonies become more and more numerous with the progress of the season, they are obliged to seek other food. It is but natural, therefore, that they should fall to preying on the Cotton Worm. It has already been mentioned that rains hinder the working of the ants, and that storms destroy them. They will, therefore, prove most effectual in assisting man where they are most protected from heavy showers, as on new land where the soil is uneven, or in fields where there are stumps, trees, &c.

To Mr. Trelease the work of the ants seemed so important as to suggest the possibility that the nectar glands of the cotton plants were originally developed by natural selection for the purpose of attracting ants which should act as protectors against the attacks of Aletia or some other enemy.

The species actually observed destroying the cotton worm have either been determined or described by Rev. H. C. McCook, and are as follows: *Dorymyrmex insanus* (Buckley), *D. flavus* McCook (variety of *insanus*), *Iridomyrmex macoooki*, *Solenopsis xyloni* McCook (=*S. geminata* Fabr.), and *Monomorium carbonarium* Smith. In addition to these, *Cremastogaster lineolata* Say and *C. clara* Mayr are found nesting in the cotton fields and may be safely counted among the enemies. For descriptions of these species see note [86a].

The most common and effective species in the Southwest is the *Solenopsis geminata* Fabr., a small species (Fig. 10) averaging 2.8[mm] in length, and of a pale fuscous color, with a darker, piceous abdomen.

Among the Dorylidæ (a family closely related to the ants and considered by some as belonging to them) we have found *Labidus harrisii*

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Hald., and *L. melsheimeri* Hald. are found very abundantly in the cotton fields, and presumably feed upon the worms.

While we have repeatedly seen this species attacking worms that were upon the ground, we have but once, at Macon Station, Ala., witnessed it feeding on a young worm on the plant; but so many correspondents have witnessed the good work of ants that there can be no question as to the general correctness of the above conclusions, though it is doubtful whether a worm is ever attacked by ants except when, from the causes mentioned, it is exceptionally helpless. Again, some species of ants are more ferocious than others, and they will act differently in different localities; hence there is a difference of opinion among planters as to their influence. We have therefore endeavored to get more reliable and extended experience on the subject, and have especially charged our assistants to make careful observations on the subject. Some of these may here be quoted. Mr. Hubbard reports as follows his observations in Florida:

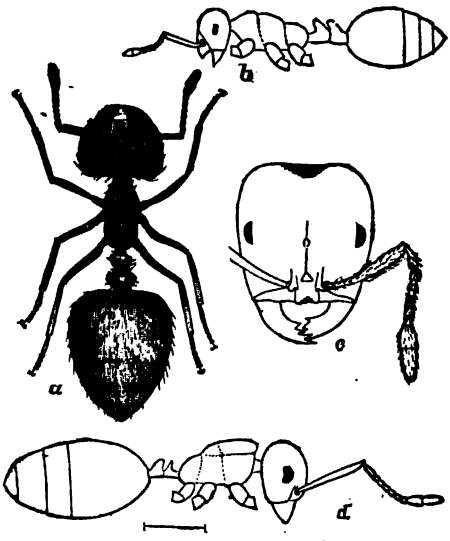

FIG. 10.—*Solenopsis geminata*: *a*, neuter, dorsal view; *b*, neuter, side view; *c*, head of neuter, front view; *d*, queen, side view. (After McCook.)

"*Ants.*—Apparently only two species are commonly found in the cotton fields, both of which are more or less predatory on Aletia. I am, however, of the opinion that the value of the services of ants in destroying the worms has been much overestimated. It is true that in the hottest weather worms which from some mischance fall upon the heated ground are soon exhausted, and often become an easy prey to ants if a colony happens to be near at hand. At such times, also, I have remarked that the stings of the latter seem to possess a greater virulence, and have a powerfully paralyzing effect upon the worms. Numerous experiments made by dropping grown worms into the midst of excited swarms of ants showed that at midday 50 per cent. and during the cooler hours 80 per cent escaped from their persecutors and found their way again on to the plants, whither they were rarely followed. I have never seen a worm attacked with any persistence when feeding on the plants; on the other hand, I have a number of times seen an ant, which had incautiously approached too near, violently flung to a distance by a blow from a worm, which, in such a case, uses the anterior half of its body as a club.

"Not once, but many times, will a caterpillar free itself by a flip of its body when seized upon the ground, while upon the plants, unless

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attacked in force, an occurrence which I have never seen, they seem to me completely master of the situation. I found that when pupæ were dropped among the ants, or placed upon the ground near their colonies, they were devoured in six or eight hours' time. Ants were often seen swarming upon larvæ and pupæ in their webs upon the plants, but in nearly, if not quite all such cases the larvæ and pupæ had been injured, possibly by a bird. I have not been able to obtain any evidence that the ants destroy the young or eggs of Aletia.

"Of the two species of ants observed, one (*Dorymyrmex flavus* McCook) is testaceous in color, timid, and very active. It runs after a caterpillar upon the ground, but does not take good hold, and is invariably thrown off. It makes quite a large cavity below the mouth of its gallery, which is also a considerable aperture. A worm dropped into this cavity usually disappears from sight for several minutes, but invariably makes its appearance again at the mouth. It finds great difficulty in getting out, even if not disturbed by the ants. Usually it is followed by a swarm of its enemies, and repeatedly falls back, but almost always gets away in the end. Several caterpillars were replaced five or six times and dropped out of sight in the galleries of strong colonies, and, although severely bitten and bleeding, they escaped at last. A few worms succumbed to the attacks of the ants after having been repeatedly thrown back.

"The second species (*Solenopsis xyloni* McCook) is dark brown, smaller, and less active, but much more courageous. It is often seen marching in columns, and makes long subterranean galleries just below the surface of the ground, with numerous exits along its course, from which quantities of finely-divided earth are thrown out. It is much more aggressive than the first species, attacks a worm fiercely, and holds on with great pertinacity, but does not follow up the attack when once the caterpillar has made its escape. It has a very severe sting, which paralyzes the worm. The latter, however, recovers if not too badly bitten. Most worms, when stung behind the middle, appear to be unable to use the anal prolegs, but can usually spring away. Sometimes the worm is entirely paralyzed, yet, if rescued in time, recovers, and I have bred the moths from such individuals. Notwithstanding its powerful weapon, I do not believe this ant can destroy a larva unless favored by chance, or unless the attack is made by great numbers and upon the ground. After the caterpillar has webbed up and become helpless, both these species of ants are occasionally found to attack it. I select from numerous field notes the following in confirmation of the conclusions I have drawn:

"August 25.—The ants do not seem to attack the young larvæ and eggs of Aletia which were crowded on the leaves, and yet they (the ants) swarm under the netting and eat up pupæ placed in jars or boxes on the ground. I think this a very fair test of the work done by the ants, since, with every condition favorable, they fail to clear off young larvæ and eggs upon plants at the foot of which they have very strong colonies.

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"August 27.—In the morning caterpillars dropped into the midst of a very strong colony of brown stinging ants (*Solenopsis xyloni*) were very quickly destroyed; some of them made hardly any effort to escape. The same colony was experimented on in the heat of the day, and four-fifths of the caterpillars escaped.

"August 28.—Experiments made with a colony of brown ants (apparently *Dorymyrmex flavus*), by dropping caterpillars in the path of a moving column, resulted in the escape of fifteen; five were killed by the ants. I have several times observed a column of the same species of ants engaged in robbing colonies of another common species and at such times they are much less inclined to attack caterpillars in their path. I have never yet witnessed the capture of a caterpillar upon the plants by ants unless it had webbed up and was stiffened to form pupa. During the hottest hours of the day the worms were more powerfully affected by the sting of this brown ant, and a greater proportion were captured by them at this time; a caterpillar sometimes succumbed after being twice stung."

The following extracts from Mr. Schwarz's notes are interesting in this connection:

"Of ants only three species were actually observed to attack worms or chrysalids, *Dorymyrmex insanus*, *Solenopsis xyloni*, and, on a single occasion, a small undetermined species. The first two species are very common, and, in my opinion, the only ones which are of importance in this Cotton Worm matter. The colonies of all these species are to be met with in the cotton fields. The former are always small and consist of round or oval subterranean excavations connected with the surface by a single, almost vertical gallery at the entrance of which no hill of upthrown soil is raised. *Solenopsis xyloni*, on the other hand, very often forms large colonies on places not disturbed by plowing or other causes. Those in the cotton fields are usually very small, without doubt on account of the frequent disturbances. There is always a hill of loose soil or sand, as the case may be, raised by this ant, through which several entrances lead to shallow but large irregular excavations below the surface of the ground. There are two or more such chambers, one above the other. A Scarabæid beetle, *Euparia castanea*, is inquilinous with this ant, and hundreds of them occur in a large colony. Its larva is found in the innermost part of the nest, and feeds upon the roots of grasses; the beetle is to be found in all parts of the nest, but rarely in young colonies.

"As to the efficacy of these two species of ants, I wish to remark that on several occasions I saw them at work destroying larvæ or chrysalides which I had every reason to suppose were in healthy condition when attacked. In one instance I saw them attacking a moth just issuing from the chrysalis. More often they attack worms which are wounded or disabled by other enemies, and pupæ which have been stung by some Heteropteron, or which are rotten. They attack fre-

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quently, however, the young larvæ in the act of molting. I never noticed them dragging, or trying to drag, dead worms into their nests. At Selma, Ala., I never saw the ants destroying an egg of Aletia. I witnessed it at Columbus, Tex., but cannot tell at present whether this egg had not been previously injured by some other enemy. When I returned from Texas I had a very high opinion as to the efficacy of these two species of ants, but since my stay at Selma, where I paid particular attention to the subject, I have modified my opinion. Out of about ten cases where the ants are seen destroying worms it is quite certain, in my opinion, that in nine of them the victim was previously severely injured by some other enemy. In spite of this fact, however, there can be no doubt in my mind that the ants, on account of their enormous numbers, are to be considered as the most important enemies of the Cotton Worm."

The reports of other agents in much the same strain seem to prove quite conclusively that the work of ants has been to some extent overrated; still their numbers must always make them important enemies of the worm. The great difference of opinion amongst observers upon this point is to a certain extent, without doubt, due to the difference in location, as in some localities the ants may be more active than in others, or different species may be concerned. It is, moreover, a question wherein preconceived ideas will have great weight in considering evidence. Take, for instance, the case of an observer who sees, upon one or several occasions, an ant in the act of devouring an egg of Aletia. He will be pardoned, perhaps, for considering this conclusive evidence of the good done by the emmets; but when we remember that many eggs are pierced and sucked by species of Triphleps and allied plant-bugs, and that in all of these broken eggs more or less of the contents is left, it becomes possible that the ants may in such case act simply as scavengers after the feast of the Triphleps. One thing seems quite conclusive, viz., that they are useful chiefly against the newly-hatched or newly-molted or disabled worms.

The leaf-cutting ant of Texas (*Oecodoma fervens*) should also be mentioned here, for when it invades a cotton field it makes a clean sweep of every worm and pupa; but it also ruins the plant, taking off leaves, blossoms, bolls, and tender stalks.

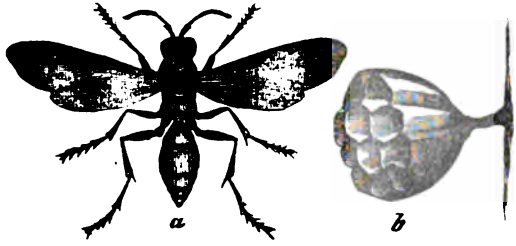

FIG. 11.—*Polistes rubiginosa*: *a*, wasp, *b*, spring nest.

Certain of the true wasps (*Vespa carolina* Drury, *V. germanica L.*), some Paper-wasps (*Polistes bellicosa* Cress., *P. rubiginosa* St. F.), and some Digger-wasps (*Sphex cærulea* De Geer, *S. pennsylvanica* Linn., and an undetermined species) occasionally carry off a worm. Of other larger Hymenoptera, *Monedula carolina*, Fabr., *Elis 4-notata*, Fabr., *E. plumipes*, Drury, *Pelopæus cæruleus*,

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Linn., *P. pensylvanica*, Linn., and *Priononyx thomæ*, Fabr., are often found in the cotton fields, and certain of them have been observed feeding on the worms. Mr. Trelease has observed *Polistes bellicosa* searching the leaves for worms, and relying on the tactile sense of the antennæ rather than on sight to find them. The instant a worm was touched, recognizing its enemy, it would throw itself from the leaf, the Polistes quickly springing after it. One wasp was observed thus to spring eight times unsuccessfully, the ninth time catching and devouring the worm. Both species of Polistes were several times seen flying about with dead caterpillars, having previously reduced them to a pulpy mass with their mandibles.

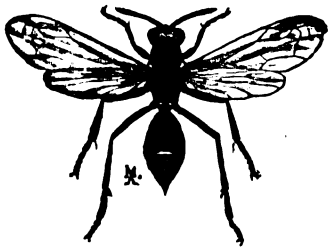

FIG. 12.—*Polistes bellicosa*. (After Comstock.)

COLEOPTERA, OR BEETLES.—Of this order numerous species belonging to the families of Tiger-beetles (*Cicindelidæ*) and Ground-beetles (*Carabidæ*) have been observed to prey upon the worms, each species being represented by but a very small number of specimens when compared with the ants. These beetles are nevertheless among the most voracious insects known to us. Most of them are nocturnal in their habits, and are thus more apt to escape the attacks of birds. They devour their prey bodily, and as they are frequently met with in cotton fields very remote from their hiding places, they are probably attracted by the smell attending the worms. The following is a list of the species actually observed feeding thereon: *Tetracha carolina* (Linn.), *T. virginica* (Linn.), *Cicindela sperata* Lec., *Cicindela punctulata* Fabr., *Calosoma sayi* Dej., *Helluomorpha laticornis* (Dej.), *H. texana* Lec., *Galerita atripes* Lec., *Brachinus* sp., *Aphelogenia furcata* (Lec.), *Callida decora* (Fabr.), *Loxandrus lucens* Chaud., *L. crenatus* Lec., *Pterostichus sayi* Brull., and *Selenophorus lævus* Lec. The number of Cicindela holes in the cotton fields is astonishingly great, the most abundant species being *Cicindela punctulata*. The larvæ drag into their holes every Cotton Worm which chances to crawl over the mouth, and many are thus destroyed during the migration of the worms, towards the end of the season. Ordinarily, however, the number of worms captured by these Tiger-beetles is very small. The accompanying cut (Fig. 14) of *Cicindela splendida* from the first report of the Commission will indicate the character of these tiger-

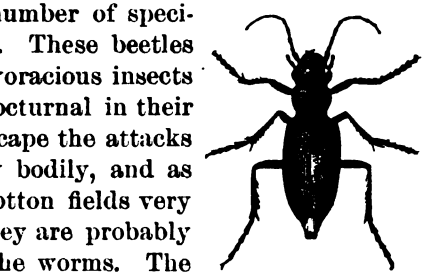

FIG. 13.—*Tetracha virginica*.

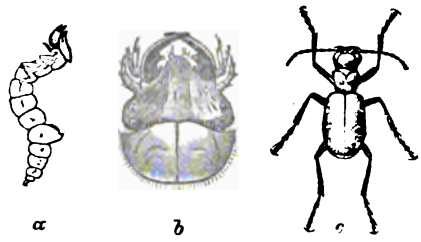

FIG. 14.—*Cicindela splendida*: *a*, larva; *b*, head of same, enlarged; *c*, beetle. (Emerton *del.*)

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beetle larvæ. *Callida decora* is an exceedingly common species in parts of the South, and both larvæ and adults destroy the Cotton Worms. The larvæ of this beetle, upon one occasion, according to Mr. Hubbard, were sufficiently numerous to cause a marked decrease in the number of the worms in certain parts of the field (at Crescent City, Fla.). They captured the young larvæ upon the leaves in great quantities, and even successfully attacked grown worms many times their own size and weight. The imago of the beetle not only destroys full-grown worms, but was found eating the chrysalides.

A number of different Lady-birds (*Coccinellidæ*) are constantly found upon cotton, and their larvæ have occasionally been observed to eat the eggs of Aletia. These larvæ have also been found to destroy large chrysalides of other moths while yet soft after the transformation, biting large holes in them and sucking the juices, and will undoubtedly be found to destroy Aletia pupæ in the same way. The small, obscure beetles with floccculent or cottony larvæ, belonging to the genus *Scymnus*, are especially abundant, but they have never been satisfactorily proven to prey upon Aletia in any state.

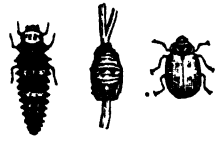

FIG. 15.—Convergent Ladybird: *a*, larva; *b*, pupa; *c*, beetle. (After Riley.)

Soldier-beetles (*Telephoridæ*) and "Fire-flies" (*Lampyridæ*) are also quite common on cotton. The beetles are pollinivorous, while the larvæ are predaceous, and in several instances have been known to destroy Aletia. Two full-grown larvæ, which we recognize as those of *Chauliognathus americanus*, were found by Mr. Hubbard feeding upon Cotton Worm chrysalides on the leaves. One of these larvæ had devoured one entire pupa and was engaged upon another when captured.

FIG. 16.—*Chauliognathus americanus*: *a*, larva; *b*, enlarged head of same; *c*, *d*, *f*, *g*, *h*, mouth parts of same; *e*, leg; *i*, beetle; *a*, *b*, natural size, the rest enlarged. (After Riley.)

We have also observed, as has also Mr. Patton, the same species feeding upon pupæ of Aletia in Alabama. In addition to what we have published on the habits and transformations of this beetle (Mo. Ent. Reports, I, p. 57, and IV, p. 28), the following notes by Mr. Hubbard on its earlier life-history are interesting:

The eggs of *Chauliognathus pensylvanicus*, which you gave me at Savannah, August 4 (my No. 62), hatched during the night of August 9. On August 10 I mounted twelve of the larvæ in balsam (Slide No. 62). I succeeded in feeding them on young *aphids* from cotton, the bodies of which I crushed. They were very timid, and ate sparingly. The color is silver gray, almost white. August 12 the larvæ retreated to bottom of earth in the bottle, and curled up in clusters. In two or three hours (10.45 a. m.) they had moulted. Their color now changed to a lead color, or mouse color. Immediately after moulting they became very active, climbing all over the sides of the jar. I gave them crushed *Phora aletiæ*, and they sucked the juice readily. They attacked the uninjured maggots, but were unable to pierce the skin. I preserved several in Wickersheim solution (No. 62, B). I gave them, August 15, a species of large, red *Aphis*, found on cockle-burr, but they did not relish them, and ate but little. They

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also ate sparingly of crushed *Aletia* larvæ, but prefer the *Phoras* to everything else. August 17 they retired to bottom of the bottle, and were torpid two days. August 19 all had completed their second moult, and are darker in color. They are now quite strong, and can pierce the skin of Phora maggots given them for food. The markings on dorsum are now quite distinct. (H. G. Hubbard, Centerville, Fla., August 21, 1880.—*American Entomologist*, III, pp. 249, 250.)

A number of other beetles, as, for instance, *Collops quadrimaculatus* (Fabr.), having carnivorous habits, are found upon the plant, and may by further observation be added to the enemies of Aletia; while a minute, yellowish-brown species (*Sericoderus flavidus* Lec.), belonging to the *Corylophidæ*, has been found feeding on the forming chrysalis while yet soft and helpless.

HETEROPTERA, OR HALF-WINGED BUGS.—Next to the ants in usefulness as natural checks are sundry species of rapacious or Soldier-bugs, as they are popularly called. These belong exclusively, so far as observed, to the families *Cydnidæ*, *Anthocoridæ*, *Scutelleridæ*, and *Reduviidæ*. They suck out the juices of their prey by means of a short but sharp beak, and the young have precisely the same habits as the mature insects, though often differing greatly in appearance. They are almost all active during the day, but a few work also at night.

FIG. 17.—*Podisus spinosus*: *a*, enlarged beak; *b*, bug, with right wings expanded. (After Riley.)

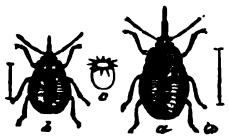

FIG. 18.—*Podisus spinosus*: *a*, pupa; *b*, larva; *c*, egg. (After Riley.)

The species actually observed destroying Cotton Worms are: *Podisus cynicus* (Say), *P. spinosus* (Dall.), *P. punctipes*, *Euschistus fissilis* Uhler, *Proxys punctulatus* (Beauv.) (see Fig. 20), *Prionotus cristatus* (Linn.), *Apiomerus crassipes* (Fabr.), *Phymata erosa* (Linn.), *Melanolestes picipes* (H. Sch.), *Stenopoda cinerea* Lap., *Œbalus pugnax* (Fabr.), (see Fig. 21), *Repipta taurus* (Fabr.), *Aceratodes cornutus* Burm., *Zelus bilobus* (Say), *Triphleps insidiosus* (Say), *Raphigaster hilaris* (Say), *Sinea diadema* (Fabr.) (see Fig. 19), and *Metapodius femoratus* (Fabr). (see Fig. 22).

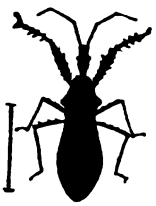

FIG. 19.—*Sinea diadema*. (After Riley.)

FIG. 20.—*Proxys punctulatus*. (Original.)

FIG. 21.—*Œbalus pugnax*. (Original.)

The spined Soldier-bug (*Podisus spinosus*, Figs. 17 and 18) seems to be perhaps the most abundant and effective of the above list. It is found all through the cotton belt, and seems to prefer to attack the full-grown worms, though it is frequently seen sucking the juices of the less protected chrysalides. Its puncture is not always fatal to the worms. Mr. Schwarz on one occasion had under his observation two worms which he thinks had been stung by the Soldier-bugs, and succeeded in both

FIG. 22.—*Metapodius femoratus*. (Original.)

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cases in rearing the moths. *Podisus spinosus* was never observed sucking the cotton bolls; but *P. punctipes* was frequently caught in the act. The bugs, however, are so closely related that their habits are probably similar.

The eggs of *P. spinosus* (Fig. 18*c*) are bronze-colored, caldron-shaped objects, with a convex lid, around which radiate fifteen or sixteen white spines. They are attached side by side, in clusters of a dozen or more, to leaves and other objects, and are very subject to the attacks of a Proctotrupid parasite of the genus *Telenomus*. The young bug is ovoid, shiny black, with some bright crimson about the abdomen. In the full-grown larva (Fig. 18*b*) four yellowish spots appear on the thorax, and the abdomen becomes more yellowish. In the so-called pupa, distinguished by wing-pads, the ocher-yellow extends still more, and in the perfect insect the black entirely disappears. In the immature stages the shoulders are rounded, not pointed. The antennæ are four-jointed instead of five-jointed as in the adult, and the feet or tarsi have but two joints instead of three.

The diet of the young seems to be principally vegetarian, but we have mentioned (Fourth Rep., Ins. Mo., p. 20) instances where the larva has often been seen to destroy larvæ of the Colorado Potato-beetle four or five times its own size.

The thick-thighed Metapodius (*M. femorata*, Say, Fig. 22), which in the first edition was placed in the list of probable enemies, has since been observed in the act of destroying full-grown worms. It has also, however, been seen to pierce and suck bolls.

Much more effective than the larger Heteroptera were two small species, both extremely abundant on cotton near Selma, and very frequently observed attacking Aletia. The one is *Triphleps insidiosus*, which, with its larva, may be considered as a special destroyer of Aletia eggs. It was very often found with its beak inserted in the eggs, busily engaged in sucking out the contents. The empty eggs, with the hole plainly observable, were also frequently met with. It was also often met with in large numbers in half-empty pupæ, which it had possibly killed; but it has not been seen to attack the worms. Another species was often seen sucking worms of all sizes and also pupæ, and even on one occasion a moth was attacked just as it was coming forth from its pupa-skin.

The following species, commonly found in cotton fields, but not yet actually observed to feed on the worms, may safely be regarded as having the habit, while several others might be added, some of which combine the carnivorous with the plant-feeding trait: *Stiretrus fimbriatus* (Say) (see Fig. 23), var. *diana* (Fabr.), *Euschistus punctipes* (Say), *E. tristigmus* (Say), *Thyanta custator* (Fabr.), *Evagoras viridis* Uhler, *Merocoris distinctus* Dall., *Anasa armigera* Say, and *Nezara pensylvanica* De G.

FIG. 23.—*Stiretrus fimbriatus*. (After Riley.)

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DIPTERA, OR TWO-WINGED FLIES.—In this order the only species that attack the worms, and probably the moths also, belong to the *Asilidæ*, a family of large, fierce flies that pounce upon other insects as a hawk pounces upon other birds, and suck their substance by means of a strong beak. But two species—one the *Proctacanthus milberti* Macq. (see Fig. 24), the other an undescribed *Asilus*—have been seen destroying the worm so far. *Asilus sericeus* has been observed to catch the moths upon the wing, afterwards eating them; while *Erax apicalis* Wied., *Diogmites discolor* Loew, and several species belonging to the above-named genera and to *Promachus*, *Laphria*, and *Dizonias* are not uncommon in the cotton fields.

FIG. 24.—*Proctacanthus milberti*. (After Riley.)

These flies deposit their eggs under ground. The following description of the act of oviposition is taken from a note by Mr. Hubbard, in the American Entomologist (vol. iii., p. 250):

"I also observed a light yellow *Asilus-fly* ovipositing in the ground in an open space between the cotton rows. She inserted her abdomen to a depth of half an inch, and deposited only three or four eggs, which I secured. During oviposition she imitated most comically the actions of a dog dropping its dung, and after finishing, immediately raked the earth into and over the hole, apparently very carelessly, but so effectively, that although I had marked with my eye the exact spot, I failed to detect it, until I unearthed the eggs. The eggs are oval, yellowish white, smooth, and quite large."

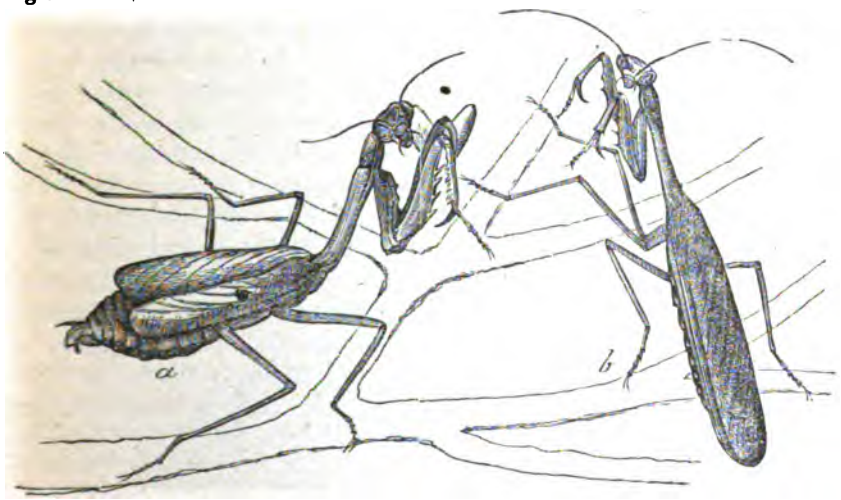

FIG. 25.—*Mantis carolina*: *a*, female; *b*, male. (After Riley.)

ORTHOPTERA, OR STRAIGHT-WINGED INSECTS.—The Carolina Mantis (*Mantis carolina* L., Fig. 25) is also occasionally found in such situations, usually confining itself to the borders of the field. It is to be

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regretted that this voracious insect is not more abundant in the cotton fields; but it undoubtedly destroys many worms. It is popularly known as "the rear horse," "the camel cricket," or "the devil's riding horse," and feeds upon all sorts of living insects. As an instance of its voracity, we have already described (First Mo. Ent. Report, p. 169) how a single female devoured eleven Colorado Potato-beetles in one night. The eggs are glued tightly together in a peculiar mass and are deposited in all sorts of situations, but principally on the twigs of trees. The eggs are extensively infested by a Chalcid parasite of the genus *Podagrion*, and the adult Mantis is destroyed by a Tachina fly.

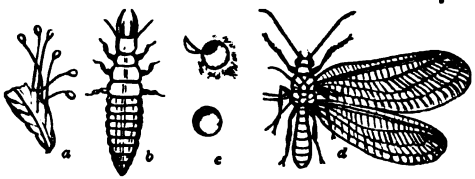

FIG. 26.—*Chrysopa*: *a*, eggs; *b*, larva; *c*, cocoons; *d*, fly, with left wings detached. (After Westwood.)

FIG. 27.—*Chrysopa* with eggs. (From Packard.)

NEUROPTERA, OR NERVE-WINGED INSECTS.—The only species of this order that are likely to prey upon Aletia belong to the Ant-lions (*Myrmeleonidæ*), the Lace-wings (*Hemerobiidæ*), and the Dragon-Flies (*Libellulidæ*). The Ant-lions work in the larva state in pits in the ground, and the constant plowing thereof will always prevent them from doing any material good, and they are naturally scarce. The Lace-wings are numerous, but their larvæ feed, like the lady-birds, on the plant-lice, and have refused to touch Cotton Worms when confined in boxes with them. The curious eggs of these flies (Fig. 27), attached to the end of a delicate filament, are often supposed to be those of Aletia. Many planters state that these flies are always to be found where there are larvæ of Aletia, and Dr. Phares states that their larvæ devour the eggs and young Cotton Worms. This is not improbable, though his statement is as yet unconfirmed by other observers. The larvæ have been seen by Mr. Trelease feeding upon the nectar of the foliar glands.

FIG. 28.—*Myrmeleon obsoletus*. (From Harris.)

FIG. 29.—*Myrmeleon* larva.

The Dragon-flies or Mosquito-hawks are aquatic in the larva state, but the perfect insects are active in their pursuit of prey while on the wing, and are reported on good authority to attack Aletia both in the worm and moth states. Fig. 30, *Libellula trimaculata*, is one of the commoner species.

Dr. F. M. McMeekin, of Morrison's Mills, Alachua County, Florida, considers them as the most valuable enemies of Aletia, and states that it is a common sight to see them catch the moths on the wing.

LEPIDOPTERA.—BUTTERFLIES AND MOTHS.—It is incontestably proven by the evidence of almost every observer we have sent into the field

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during the past five years that the Boll Worm (*Heliothis armigera*) when approaching full growth develops a strong, carnivorous appetite, and not only destroys the smaller worms of its own species, but also enters the loose cocoon of the Cotton Worm and feeds upon the inclosed pupa. There is good evidence that the Grass Worm (*Laphygma frugiperda*) occasionally eats the Cotton Worms, a fact which seems probable from the known habits of *Laphygma*, and even the Aletia larva, like many other species of its order, when hard pressed, will develop cannibal propensities.

FIG. 30.—*Libellula trimaculata.* (After Sanborn.)

PARASITES.

Up to the time of the appearance of the first edition of this work in January, 1880, or rather up to the time of the appearance of a preliminary article by us in the *Canadian Entomologist* for September, 1879, no parasites of the Cotton Worm had been recorded by name so as to be recognized by entomologists, and the belief was quite general that Aletia was entirely free from parasitic checks. This belief, as we have already seen, was used by Mr. Grote as an argument in favor of the arrival of Aletia *de novo* from some foreign country whenever it appears with us. The fact remains, however, that one of the most important of these parasites had been mentioned without name by six writers at least, and that two tolerably good figures of the species had been published. Indeed, the very fact of the existence of such a parasite had been used by Dr. Gorham to found a theory similar to Mr. Grote's, as we shall show under the head of "History of the literature."

The following species have been discovered since we began this Cotton Worm investigation. The observations of the past two years have added four parasites to those published in the first edition of this work: Infesting and issuing from the egg:

(1.) *Trichogramma pretiosa* Riley.

Infesting and issuing from the worm (the parasitism of No. 5 doubtful):

(2.) *Apanteles aletiæ* Riley.
(3.) *Euplectrus comstockii* Howard.
(4.) *Sarcophaga sarraceniæ* Riley.
(5.) *Cyrtoneura stabulans* Fallen.
(6.) *Tachina aletiæ* Riley.
(7.) *Tachina fraterna* Comstock.

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Infesting and issuing from the chrysalis:

(8.) *Pimpla conquisitor* Say.
(9.) *Pimpla annulipes* Br.
(10.) *Cryptus nuncius* Say.
(11.) *Chalcis ovata* Say.
(12.) *Cirrospilus esurus* Riley.

Species issuing from the chrysalis and not true parasites of Aletia, though easily mistaken for such:

(13.) *Hexaplasta zigzag* Riley.
(14.) *Phora aletiæ* Comstock.

Infesting and issuing from the Egg.—THE TRICHOGRAMMA EGG-PARASITE.—(*Trichogramma pretiosa* Riley)[29]: Attacking *Aletia* in its earliest state, the unhatched egg, this winged atom must be, when abundant, a most effectual check, and the scarcity of the Cotton Worm in certain seasons may doubtless be partly ascribed to its work. It is at least known that a similar egg-parasite has in the New England States relieved the shade trees from the ravages of Canker-worms—a good deed which the European sparrows, notwithstanding they received the credit for it, were unable to accomplish. This Trichogramma is a yellow fly, so small that were it not for its activity in jumping it could not be distinguished by the unaided eye as an animated being, and it finds sufficient nourishment in a single egg of the Aletia to support its growth and maturation. It emerges from a round hole which it gnaws through the egg-shell, and eggs infested by it or which have been destroyed by it may be recognized by their bluish or blackish color or the presence of this perforation. When examined under the microscope, the perfect fly is found to be an object of much beauty, the hairs upon the wings being arranged in regular lines. Some specimens of both sexes—the male may be distinguished by the bristly antennæ—were found to have one or more of the wings imperfectly developed, presenting the appearance of a paddle. The accompanying figure (Fig. 31) will serve to illustrate its character and render further description unnecessary.

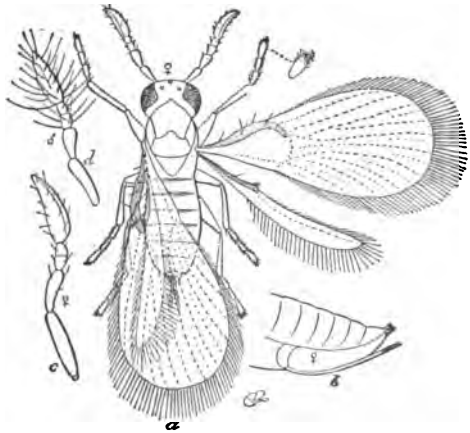

FIG. 31.—*Trichogramma pretiosa*: *a*, female; *b*, tip of female abdomen; *c*, female antenna; *d*, male antenna (all greatly enlarged). (Original.)

This minute creature was first noticed by Professor Comstock in 1878, near Selma, Ala., and in October, 1879, we found it quite common in Mississippi, Alabama, and Georgia, fully one-fifth of the eggs in some fields being infested. Mr. Schwarz found it rather rare in Texas, and

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according to Mr. Hubbard it is very abundant in Florida. The observations of the latter are interesting and well illustrate the importance of the species. He found that this little egg-parasite, unaided and alone, almost completely annihilated the fifth brood. At the beginning of the fourth brood less than half the eggs of Aletia were destroyed. July 27, when the eggs of this brood had nearly all been deposited, about 75 per cent. were found to have been parasitized, the proportion in some parts of the field reaching 90 per cent. About the middle of August, while the eggs of the fifth brood were being laid, the proportion destroyed by the Trichogramma exceeded 90 per cent. in all parts of the fields, while, at the brood centers, careful estimates showed that but three or four eggs out of a hundred escaped. He gives the following account of the eggs of the species:

"The mother works chiefly by day, depositing two ova in each egg of Aletia or Heliothis. The eggs of the parasite hatch in forty-eight hours, while that of their host darkens, and in a few days turns almost black. On the seventh day after being stung it is vacated by the parasites, which issue through an irregular hole gnawed in the side, each making its own opening. Frequently after the inclosed parasites have formed their pupa the shell of the Aletia egg shrinks about them, leaving two little oval cells indicating the positions of the parasites within. A day or

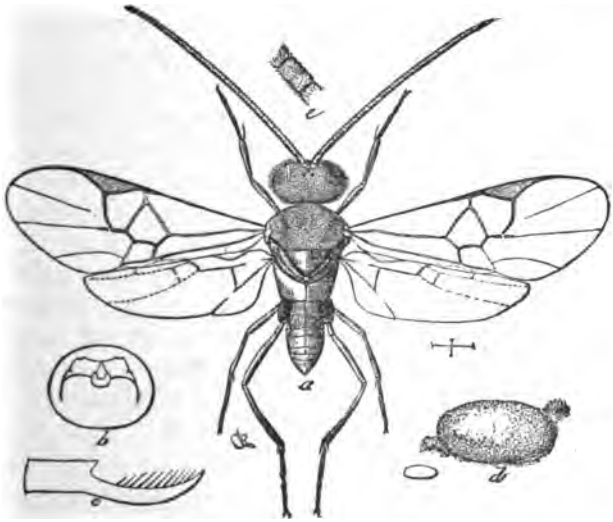

FIG. 32.—*Apanteles aletiæ*: *a*, female fly; *b*, outline of head of larva in position to show the chitinized parts of the mouth, the mandibles not visible, being withdrawn; *c*, one of its mandibles as seen within the head of a mounted specimen; *d*, cocoon; *e*, joint of antenna—all enlarged: nat. size of *a* and *d* in hair-line (after Riley).

two before they issue the ruby-colored pupæ of the parasites can be plainly distinguished through the translucent shell of the destroyed egg. I have invariably obtained two Chalcids from each discolored egg of Aletia or Heliothis collected."

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Our experience accords with that of Mr. Hubbard, though the number infesting a single egg is not invariably two. We have often obtained but one from a single egg, and, according to Mr. Schwarz's experience, three may exceptionally be obtained. As will have been gathered from Mr. Hubbard's notes quoted above, the Trichogramma has been raised from the eggs of *Heliothis armigera*—the Boll-Worm moth. It has also been reared from the eggs of *Laphygma frugiperda*, the Grass-Worm moth, and from the eggs of an unknown Tortricid on orange. We have also found a minute yellow parasite of somewhat similar general appearance and easily mistaken for it, but in reality very distinct when carefully examined, infesting the larva and the pupa of an undescribed Aleurodes that is common on cotton, two or more flies issuing from each Aleurodes.[29a]

Infesting and issuing from the Worm.—THE COTTON-WORM MICROGASTER.—This species, described by us as *Apanteles aletiæ*,* has been very frequently found during the past few seasons in Florida, Alabama, and Texas.[30] The egg is laid in the posterior portion of the body of partly-grown larvæ of Aletia (never in very young or full-grown worms). It is a solitary parasite, only one specimen infesting a single Cotton Worm. We quote the observations upon the species made by Mr. Hubbard, who has watched it more carefully than any of the other agents: "Late in August, while the worms of the fifth brood were in process of development, I discovered on the underside of lower leaves of cotton and upon grass growing under the shade of the oak tree at the center of this brood, a number of little oval cocoons of white, flossy silk, about 4^{mm} (0.16 inch) long. Close beside these dangled the dead body of a young cotton worm, suspended from the leaf or from the cocoon by a thread of silk. In about a week each cocoon produced a Microgaster (most of my notes relating to this parasite having been lost, I am unable to give the exact periods in which it undergoes its transformations). Subsequently I observed the larva, naked and memberless, its body tinged with green by the juices of its prey, in the act of spinning its cocoon. The larva forms the exterior by throwing out loops of ropy fluid which, under a lens, are seen to become rigid as they fall, and to harden rapidly, forming rather a coarse strand of white silk, which is often beautifully furred. These loops are piled one upon another and the walls of the cocoon rise rapidly until they meet overhead. The inside is lined in the manner usual with lepidopterous larvæ until the whole has become opaque. The process of spinning occupies about two hours' time. After August 20, nearly all the young larvæ of Aletia collected were found to contain this parasite, which kills and emerges from the worms when they have attained a quarter of their full growth. In quitting its host the parasite maintains its connection with the body

* Transactions of the Academy of Science of St. Louis, Vol. 4, No. 2.

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of the latter by means of a single thread. After crawling to a distance of about half an inch it fastens this thread to the surface of the leaf, and begins its cocoon. The body of the caterpillar is dislodged in time, and falls from the leaf, but usually remains suspended by the connecting thread. As the parasitic grub within its body increases in size, the young caterpillar weakens and often falls to the ground, in which case the parasite climbs the nearest blade of grass and there makes its cocoon."

In escaping, the fly makes a lid-covered opening in the cocoon, as do the other members of the genus. Mr. Schwarz is of the opinion that this parasite does not always kill the worm, as upon several occasions he raised to the perfect state worms which were scarred upon the posterior end of the body, just as if one of these parasites had emerged. Two secondary parasites have been bred from the Apanteles—the one a Chalcid[31] and the other an Ichneumonid belonging to the genus *Hemiteles*.

Comstock's Euplectrus.—Professor Comstock, in the Report on Cotton Insects, 1879, figured and quoted passages from his notes concerning a parasite of the Cotton Worm, which he called "the unnamed Chalcid." In the August (1880) number of the *Canadian Entomologist* the species was described by Mr. Howard as *Euplectrus comstockii*. This description he has somewhat revised, and it will be found in the notes.[32] During 1880 this parasite was studied by us and by different agents of the Commission in Alabama and Florida, and in the January (1881) number of the *American Naturalist* Mr. Schwarz gave a very full account of its life history. From this article we take the following facts:

The egg of the parasite is elongate oval, strongly convex above and somewhat flattened beneath; no sculpture is visible under an ordinary lens. Its color is uniformly brown, and almost black just before hatching. The number of eggs laid by the female Euplectrus on a single Cotton Worm varies from one to fifteen, the most common numbers being three, five, and seven. They are always laid in a group, the individual eggs sufficiently separate from each other to allow room for the development of the larvæ. It seems altogether probable that the time required for the development of the eggs does not exceed two days. The Cotton Worms attacked by these parasites are usually less than one-third grown, but not less than one day old. The eggs of the parasite are laid on the middle of the back of the worm, sometimes a little to one side or the other, and upon one occasion they were seen fastened just above one of the middle pair of thoracic legs.

Fig. 33.—Aletia larva infested by larvæ of *Euplectrus comstockii*. (Original.)

The delicate egg-shell splits longitudinally and discloses the white larva, which gradually works the shell down the sides of its body until, in less than twelve hours, it disappears below the rapidly-growing para-

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site. This last, as soon as it has freed its head from the egg-shell, pierces the skin of its victim and thereafter remains stationary with its head buried. As soon as it has fairly begun to feed the white color changes to a bright bluish-green. The growth of the larva is very rapid, but seems to vary according to the season, averaging three days in August and four days in September. When full-grown, the larvæ crowd each other, and if there are five or more of them on a caterpillar they form a semi-globular lump of very striking appearance. (Fig. 33.) Usually their growth is uniform, and retardation in development of individuals in the group results in death. When full-grown they turn yellowish-white and relax their hold. The worm, which up to this time showed no signs of being affected, except by its sickly yellowish color and by its very slow growth, collapses and dies as soon as a single one of the parasitic larvæ withdraws, and the same fate overtakes those Euplectrus larvæ which are at the time less advanced in their development or immature. If one of the parasitic larvæ be removed by hand, both the victimized worm and the remaining parasites quickly dry up. The parasitic larvæ always remain stationary on the worm which the parent fly has chosen as its victim, and they never even move from the spot where the egg has been laid until they are full-grown. Every attempt made to transplant a parasite from one worm to another invariably resulted in the death of the parasite.

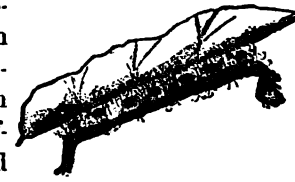

FIG. 34.—Larval skin of Aletia fastened to a leaf by Euplectrus cocoons. (Original.)

In preparing for pupation, the larvæ manage, by a peculiar elongation and sudden contraction of their abdominal joints, to work from the back of the worm to the ventral or attached side, where they spin fine, silken threads which more fully secure the worm, which is now a mere empty skin, to the leaf. As the Euplectrus larvæ take their places side by side, the caterpillar skin is fastened its whole length to the leaf, if there are five or more of the parasites; but if there are fewer, only one portion of the skin, usually the anterior end, is fastened, the remaining portion either hanging down or breaking off. This web of the Euplectrus larvæ consists of an irregular mesh of yellowish-white silk, recalling some kinds of mold, and is spun to secure the caterpillar skin to the leaf, in addition to a few other threads to prevent the pupa from being moved from its place. (Fig. 34.) Protected by the caterpillar skin as by a roof, the Euplectrus larva changes to a pupa, the color of which is dark honey-yellow, with the head and abdomen very soon becoming pitchy black. The duration of the pupa state varies from three to eight days. The Euplectrus is subject to the attacks of a secondary parasite of its own family (*Elachistus euplectri*),[33] and its pupa is sometimes destroyed by another enemy, probably some Carabid beetle. It is very common in the vicinity of Selma, and in October, 1880, in company with the *Apanteles aletiæ*, it caused the almost complete de-

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struction of the worms. This species—*comstockii*—is by no means confined in its attacks to Aletia larvæ, but has been bred from or

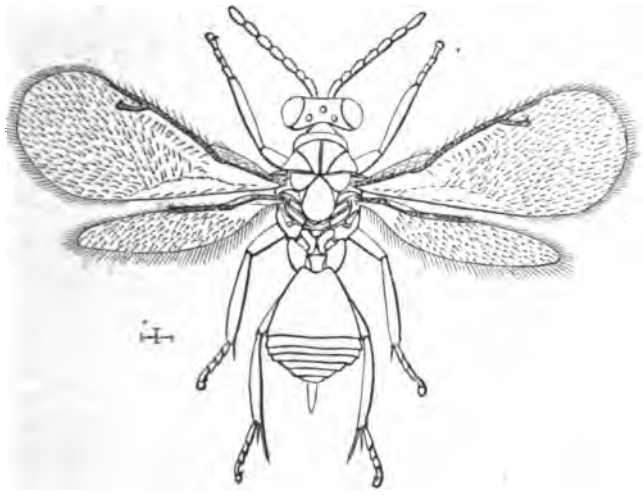

FIG. 35.—*Euplectrus comstockii:* female. (After Comstock.)

found upon *Prodenia lineatella* and *Laphygma frugiperda*. From the Laphygma twenty-five parasites were reared from a single larva.

THE COMMON FLESH-FLY.—Several species of flies belonging to well-known parasitic genera have been found to infest the worm. One of these is the common Flesh-fly, and a male specimen bred from Aletia does not differ[34] materially from small specimens obtained from the decaying insects found in the pitchers of the spotted pitcher-plant (*Sarracenia variolaris*), and to which we have given the name of *Sarcophaga sarraceniæ*.

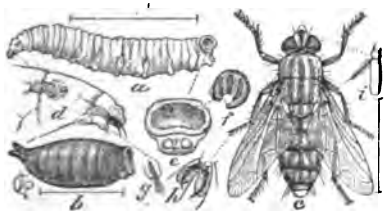

FIG. 36.—*Sarcophaga sarraceniæ: a*, larva; *b*, pupa; *c*, fly, the hair lines showing average natural lengths; *d*, enlarged head and first joint of larva, showing curved hooks, lower lip (*g*) and prothoracic spiracle; *e*, end of body of same, showing stigmata (*f*) and prolegs and vent; *h*, tarsal claws of fly with protecting pads; *i*, antenna of same. All enlarged. (After Riley.)

These flies (Fig. 36) lay elongate and delicate eggs, which hatch very quickly. They sometimes hatch, in fact, within the oviduct, so that the fly gives birth to living maggots. The maggot penetrates the skin of the worm or the chrysalis, as the case may be, and feeds upon the fatty tissues within, acquiring full growth and issuing sometimes before but usually after its victim has transformed to the chrysalis state. Dropping to the ground, it burrows beneath the surface, and rapidly contracts to the pupa state, from which the perfect fly in due time issues. The species has been obtained from the Cotton Worm in Alabama, Georgia, and Texas, and is indeed widespread over the country. It is most abundant in autumn, and passes

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the winter in both the pupa and fly states. From the known preference of this fly for decaying or putrescent flesh, it is probable that the female is attracted more to diseased or injured chrysalides than to vigorous worms.

Another species (*Cyrtoneura stabulans* Fallen, Fig: 37), the habits of which are rather predaceous than parasitic, was figured and described, but not identified, in the Department Report on Cotton Insects. We may appropriately consider it here, though it really preys upon the chrysalis. Seven larvæ emerged from eggs which had been deposited upon the leaves surrounding Aletia pupæ, and reached full growth in ten days, having meantime devoured six Aletia pupæ. They then entered the ground and remained in the pupa state five days.

We have also obtained this fly from Aletia chrysalides, and quote the following passages from the *American Naturalist* (September, 1882, p. 746), as bearing on the question whether it is a parasite or a scavenger:

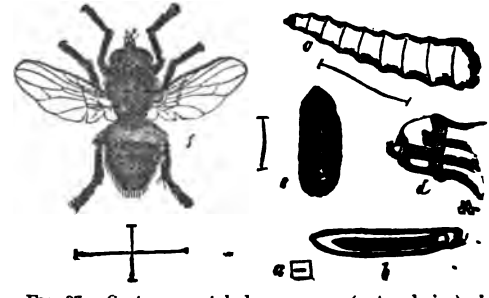

FIG. 37.--*Cyrtoneura stabulans: a*, egg (natural size); *b*, egg (enlarged); *c*, larva (enlarged); *d*, head and first thoracic segment of larva, still more highly magnified; *e*, puparium; *f*, adult, natural size indicated by hair lines. (After Comstock.)

"IS CYRTONEURA A PARASITE OR SCAVENGER?—Last spring we sent specimens of a Muscid for determination to Mr. R. H. Meade, Bradford, England, and he kindly wrote us as follows regarding this species which was bred from chrysalides of the Cotton Worm:

"The Dipterous insects which I received yesterday are one male and two females of *Cyrtoneura stabulans* Fallen. This fly is common throughout Europe, and also occurs in North America, according to Loew and Walker (see Osten Sacken's Cat. of Dipt. of N. A., edit. 2d, p. 163). The larvæ usually feed upon decaying vegetable substances, as fungi, &c., but Schiner (Fauna Austriaca, Dipt., Vol. 1, p. 597) says, according to Bremi and Hartig, they also live upon the larvæ of Lepidoptera and bees. It is a very interesting fact that they also eat the Cotton-worms. Your American specimens seem to be perfectly identical with my British ones, but are rather smaller. I may add that the genus Cyrtoneura Macq. belongs to the family of the true Muscidæ."*

There can be no doubt that the Cyrtoneuras we bred issued from pupæ of Aletia, but as the usual habits of the species are those of a scavenger, some doubt has arisen in our mind as to whether it is a true parasite. We recall to our readers another dipterous insect, the *Phora aletiæ* Comstock, which has been called, by its describer, one of the most important parasites of the Cotton-worm, and which nevertheless turns out to be a mere scavenger. *Cyrtoneura stabulans* may, like this Phora, lay her eggs on the decaying pupæ of Aletia, which are so commonly met with at the time the worms have defoliated the fields and have also eaten the leaves which sheltered the chrysalides. These chrysalides when exposed to the light and heat of the sun are very liable to rot, and on examining the chrysalides hanging on the defoliated plants, by far the larger portion of them will be found to be rotten, many containing

*See also Mr. Meade's note on the same subject in the (London) *Entomologist*, June, 1882, pp. 140–141.

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the larvæ of Phora, some the larva of this Cyrtoneura, while the largest portion contain only a badly smelling fluid. If further observations prove that this fly infests only such chrysalides and cannot be bred from the living Aletia larva, it cannot be considered a true parasite.—*C. V. Riley.*

THE TACHINA FLIES.—The other Dipterous flies belong to the genus *Tachina*. The first of these was described by us in the *Canadian Entomologist*, 1879 (Vol. XI, p. 162) as *Tachina aletiæ*,[35] and is the most abundant Dipterous enemy of Aletia. It measures about one-third of an inch in length, and is more robust and slightly larger than the common house-fly, from which, as well as from the *Sarcophaga* (which is less robust than the *Tachina*), it may be distinguished by having the bristle of the antennæ smooth and not hairy. These *Tachina* flies are more completely parasitic than the flesh-fly above mentioned, and their eggs are harder, more polished, and very firmly attached to the worm, usually just behind the head, where they cannot be molested. The larvæ or maggots have the same habits and mode of transformation as those of *Sarcophaga*, and the accompanying figure (Fig. 38) of *Tachina flavicauda* Riley, will serve to illustrate the flies. Occasionally these maggots are not full fed, and do not destroy the Aletia till after it has assumed the chrysalis state, but ordinarily they issue from the worm itself, which is frequently infested by more than one. The species was reared from chrysalides sent by Mr. Grote from Savannah and by others from various parts of the South, including the States of Alabama, Mississippi, and Texas.

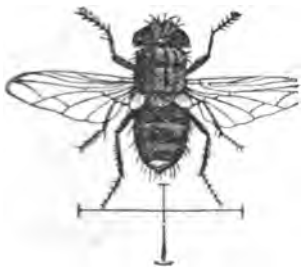

FIG. 38.—Yellow-tailed Tachina-fly. (After Riley.)

Another species of Tachina has been described by Professor Comstock (Annual Report of Commissioner of Agriculture, 1879, p. 303)[36] as *T. fraterna*, resembling *T. aletiæ* quite closely, but found to differ upon careful examination.

The number of worms killed by these Tachinid flies is very hard to estimate. Their eggs are very common on the backs of the cotton caterpillars, especially towards the end of the season, occasionally as many as 8 or 10 eggs being found upon a single worm. Observers have estimated at different times the proportion of worms thus parasited, and it has occasionally reached as high as 40 per cent.; but all who have observed these parasites at all have been struck by the fact, in the first place, that a very large number of the eggs are discarded with the cast-off skins at molting, and so the larvæ which hatch die for want of sustenance, and, in the second place, that the Tachinid larvæ destroy one another quite as readily as they feed upon the caterpillars. It is true that Mr. Trelease has recorded an instance in which a skin was shed without removing an egg, but this we must regard as exceptional. The

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reader interested in the minute differences that separate the maggots of these two genera, *Sarcophaga* and *Tachina*, which similarly affect the Cotton Worm, is referred to the notes.[37] Mr. Hubbard has made some interesting observations on the larval habits of one of these insects, probably Sarcophagid, which we quote:

"Another fly, Tachinid (?), destroys the pupa of Aletia, but appears to be rather predatory than truly parasitic. Its eggs are white, elongate, and longitudinally carinate. I have found them deposited upon the muslin covering of jars containing pupæ of Aletia and Heliothis, and also in the field within the webbed-up leaves containing the chrysalis of Aletia. The following notes give all that I have preserved relative to their natural history. Tachinid (?) fly. Eggs laid August 9 or 10 on muslin cover of jar No. 2, which contained several pupæ of *Heliothis armigera*, all covered with earth, also feeding worms of same, with frass and cotton leaves, bolls, &c. Eggs hatched during the night of August 11, and the maggots disappeared into the jar. Two flies emerged from beneath the surface of the earth August 17. August 19, examined the jars and found several pupæ destroyed by the fly maggots, also two or three puparia from which the flies had not yet emerged.

"August 5. Found in the field an Aletia pupa, containing a moth fully formed, but from which the maggot of a Tachinid (?) fly was rapidly pushing off the pupa covering. It rooted about with its hooked jaw like a hog, and very soon had the body of the moth reduced to fragments. In about three hours the contents of the moth's body were transferred to that of the maggot, which rapidly increased in size and pupated to-day. As I saw the maggot almost when it first began its work, and it was then more than half grown, I am at a loss to understand how this footless grub managed to reach this pupa after having been partly fed upon another pupa and on another leaf. In a search made to-day in the field I found another nearly full-grown maggot, but in this case there were two Aletia pupæ webbed in the same leaf. The maggots had already entirely eaten one of them and was feeding upon the second. On August 5 I found the first specimens of this maggot, but only noticed in one case that there was a second pupa of Aletia webbed on the same leaf. In my breeding-vials, if several of these maggots are confined together, and the slightest scarcity of food exists, they turn upon each other. I believe the mother fly nearly always lays two or more eggs together. The young maggots are thus enabled to destroy very rapidly and eat the whole of a pupa, a part of which would dry up if there was but one maggot. When all the food is consumed the maggots eat each other, until but one is left. In this way a single pupa will suffice for a maggot, because there is no waste. In the field these maggots are becoming more numerous, but are not by any means abundant.

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"August 20, on the under side of a lower leaf (cotton), I found two dipterous maggots, each about three lines long and apparently identical with those found eating the pupa of Aletia. On this leaf were no other living objects, except a few minute Aphids. The maggots were busily exploring the surface of the leaf, raking it with their jaw-hooks, but without cutting the epidermis. To one of the maggots I gave the crushed body of a hemipteron, upon which it fed for a short time only. I then gave it one-half of the body of a caterpillar, which it immediately entered from the ruptured end and began feeding ravenously. The other maggot I placed upon the body of a living caterpillar. It at once took hold with its hook and began to twist its body round and round like a gimlet. The caterpillar winced several times, and five minutes later it plucked the maggot off with its jaws and jerked it to such a distance that it fell clear off the leaf and upon the ground. The maggot appeared to be injured, and afterwards refused to take hold when replaced upon the caterpillar. The other maggot was placed upon the body of a living caterpillar, but was thrown off again without securing a hold. I afterwards killed a caterpillar by pinching, without rupturing its head, but this the maggot refused to bore into. These maggots were afterwards fed upon Aletia pupæ, which at first I had to crush for them. When nearly full grown, having been accidentally overlooked and ill supplied with food, I found each in the act of eating the other, and, of course, both died."

Issuing from the Chrysalis.—The foregoing species issue in the larva or maggot state mostly from the worm, and usually undergo their transformations independently of their host. All the other parasites yet to be mentioned undergo their transformations within the chrysalis and gnaw their way out of the more or less completely emptied shell as perfect insects. The Aletia is attacked, however, in the larva state, the parent parasite stinging and laying her eggs beneath the skin of the worm, the parasitic larvæ affecting the vital parts only after the transformation of the victim to the chrysalis state.

THE WATCHFUL PIMPLA.—This species (*Pimpla conquisitor*, Say [38]) sometimes destroys from 15 to 20 per cent. of the last brood of Aletia, and the chrysalides that are whole and that appear sound or alive after a good frost are found to contain its larva or pupa in still greater proportion. It has been obtained from Aletia from all parts of the South, and by most of the observers and agents of the Commission, the fly issuing sometimes in the fall, but mostly in spring. It is a black, four-winged fly, varying in length from one-fourth to one-half of an inch, and may be distinguished from other native species of the genus *Pimpla* by having the margins of the abdominal segments white. The exserted ovipositor does not exceed one-half the length of the abdomen, and the male may be recognized by the absence of an ovipositor and by his more slender body. Say reared the species from a follicle of a case-bearing Bombycid moth with transparent wings, probably the common Bag Worm (*Thyri-*

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dopteryx ephemeræformis, Haw.), although Walsh (Trans. Acad. Sci. St. Louis III, 137) identifies Say's Bombyx with *Olisiocampa americana*.

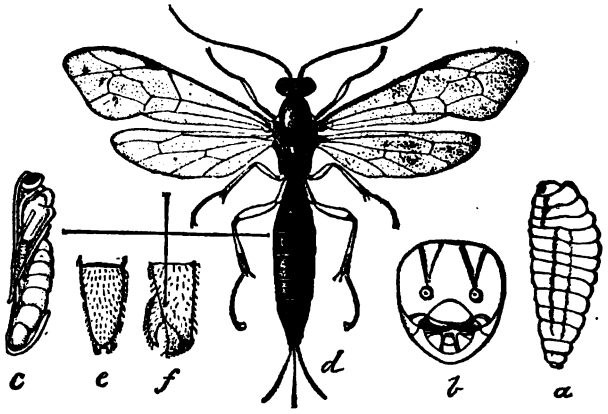

FIG. 39.—*Pimpla conquisitor*: *a* larva; *b* head of do. from front; *c* pupa; *d* adult female (hair line indicating natural size); *e* end of male abdomen from above; *f* same from the side—all enlarged. (Original.)

The *larva* (Fig. 39 *a*) of *Pimpla conquisitor* is a legless maggot of a whitish color, the head well defined, concolorous with the body and with distinct mouth parts; the tips of the mandibles black. The body tapers posteriorly, the skin is finely wrinkled, and no spiracles are apparent; the first three joints have a longitudinal, impressed line low down on the sides, and the succeeding joints have a similar line higher up, and above it a distinct lateral ridge or series of protuberances. The mandibles are slender and pointed, situated beneath the labrum and above the three fleshy tubercles which represent the maxillæ and labrum. Above the labrum are two distant and very indistinct circles with a minute point in the center, indicating the position of the antennæ. The largest larva examined measured 9mm.

The *pupa* (Fig. 39 *c*) resembles the imago in the form of body, but the colors are undeveloped, the wings unexpanded, and the legs, antennæ, and palpi laid along the sides and breast. In the ♂ the tip of the abdomen is abruptly terminated, and just before the tip on each side is a tubercle bearing two projecting teeth; in the ♀ the ovipositor is curved up over the back.

The species is widely distributed over the United States and attacks a large number of other lepidopterous larvæ. It is probably the most effectual as it is the most noticeable check to the development of the chrysalis, and that it has always attacked Aletia seems most probable; for the following account by Dr. Gorham, published in 1847 in the article in De Bow's Review already cited, gives such an exact account of it and such a full general description, that, while he could not name it, there is no question as to its identity with the species under consideration. In endeaving to explain the disappearance of the Cotton Worm in early winter, Dr. Gorham writes:

Let us take a pocketful of these [the chrysalides] home and place them beneath tumblers, and wait patiently to see what they will produce. * * * About the fifteenth of November the insect appeared, but, *mirabile dictu!* as different from the Cotton fly as it is possible to suppose one insect could differ from another. It belonged altogether to a different family, a description of which I give as follows:

Antennæ filiform; black, six lines in length. Palpi four, two external and two intermediate, the external white, twice the length of the other two, in shape angular, the angles projecting externally. The two middle are straight, scarcely perceptible

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over a strong light; they are of a dark color. Wings four; hymenopterous; incumbent, extending to and exactly even with the end of the tail; shape of the wings, which are small and extremely delicate, like that of a fan. Front legs half the length of the posterior, of a uniform orange color; the intermediate legs very little longer than the anterior; the thighs of a deep orange color, the rest of the leg annulated with orange and white. The posterior legs long in comparison to the others; thighs of a deep orange color, the rest of the leg annulated with black and white, the rings being larger than those of the intermediate. The trunk is of a uniform shining black, as would be the upper surface of the abdomen also were it not for the very narrow white bands which connect the black scales together, giving to the abdomen an annulated appearance; these white lines do not encircle the abdomen, but terminate uniformly on the sides. On the under surface of the abdomen these white rings again commence, which are larger than those on the upper surface, causing the abdomen to look almost white. The tail terminates in a bifurcated sheath, inclosing a long blunt sting, projecting considerably beyond the tail, and forming a very prominent feature in the general figure of the insect. This is a small, slender insect, much longer than the honey bee, but not so thick.

In 1851 Mr. Affleck figured and described what is probably this species in his Rural Almanac. In 1855 Mr. Glover also treated of the same parasite. The other public mentions were by Glover in 1867, Phares in 1868, and William Jones in 1868.

The Watchful Pimpla is rarely, if ever, bred from Aletia, except late in the fall, when it is occasionally found in great numbers (*vide* the experiences of Affleck, Gorham, and Jones), and it seems altogether probable that during the summer months this parasite prefers other caterpillars, resorting to the Cotton Worms only at the end of the season, when other caterpillars are wanting or very scarce, Aletia being one of the last species of the season. This parasite usually hibernates as a pupa within the Aletia pupa, but often issues in the fall.

THE RING-LEGGED PIMPLA.—This is another species (*Pimpla annulipes* Br., Fig. 40) of the same genus, having about the same size and general appearance, but having the rings on the abdomen dusky or reddish instead of whitish, and differing in other minute particulars. It is less numerous than the preceding, but we have obtained it from chrysalides on several occasions. In habit it is precisely like *conquisitor*, and equally widespread and destructive to other species of lepidoptera, being one of the few parasites of the common Apple Worm (*Carpocapsa pomonella*).

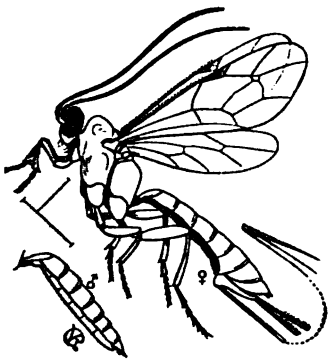

FIG. 40.—*Pimpla annulipes:* Outline side view of female and of male abdomen. (After Riley.)

CRYPTUS NUNCIUS (Fig. 41).—A third Ichneumon-fly, belonging to a different genus and having similar habits with the Pimplas just described, except that the pupa is formed in a cocoon, may (considering the the known variability of coloration in the species of the genus) be referred to *Cryptus nuncius*, Say. It is a black and red, four-winged fly, with transparent wings, and issues from the Aletia chrysalis during the spring. It is a well-known parasite of our

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large native silkworms, *Callosamia promethea*, *Samia cecropia*, and *Antheræa polyphemus*, from the cocoons of which it emerges in the Northern States early in the spring, a considerable number of the parasites appearing from a single cocoon.

A female specimen from Aletia has the head and thorax black, the 8th–10th joints of the antennæ white, the palpi black, the legs including all the coxæ red, with the tips of the posterior femora and of the posterior tibiæ black, and the posterior tarsi tinged with brown. The first four joints of the abdomen are entirely red, the succeeding joints and the sheaths of the ovipositor black, the ovipositor itself reddish; the apical joints of the abdomen have a white spot above. Relying upon the length of the ovipositor as a character for separating *nuncius*, Say, from *samiæ*, Pack.,(39) the female of the present species may be distinguished by the ovipositor being much shorter than the abdomen, as shown in Fig. 41, *b*; Fig. 41, *a* representing *Cryptus samiæ*. Fig. 41 *c* indicates the form of the abdomen in the male.

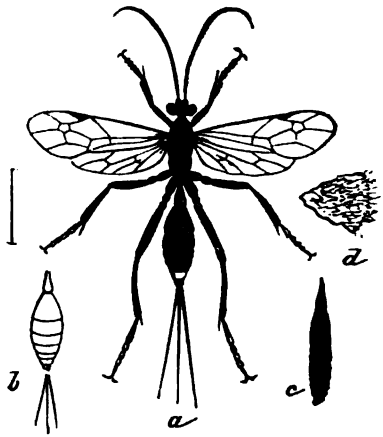

FIG. 41.—*Cryptus samiæ*: *a*, female; *b*, female abdomen of *O. nuncius*; *c*, male abdomen; *d*, highly magnified piece of wing—hair-line showing natural length. (After Riley.)

THE OVATE CHALCIS (Fig. 42).—In the next family (*Chalcididæ*) to the *Ichneumonidæ*, to which the preceding three species belong, we have two parasites which issue from the pupa, the larger and more abundant of which is the Ovate Chalcis (*Chalcis ovata* Say). It is one of the largest of the North American Chalcids, measuring 5^{mm} in length, and may be readily distinguished from the other Cotton Worm parasites by its swollen hind thighs and by the glassy appearance of its abdomen. The species is also easily distinguished by the hind thighs being black, with a yellow spot at tip, and by the tegulæ being entirely yellow. The species is widespread in the United States, and occurs also in Mexico and the West Indies. We have reared it from Aletia chrysalides collected by Professor Willet in Georgia, Professor Comstock in Alabama, Mr. Schwarz in Texas, Dr. Anderson in Mississippi, and by us in the first-mentioned State and in North Carolina; while we have likewise reared it from *Desmia maculalis* (the Grape leaf-folder), in Missouri, and found it commonly infesting the chrysalides of certain Hackberry-feeding worms (*Apatura lycaon*, Fabr., and *A. herse*, Fabr.) in several of the Southern States.

Unlike the Watchful Pimpla, the Ovate Chalcis seems to be almost equally abundant throughout the season, increasing but little towards fall. Mr. Schwarz is of the opinion that the species is perhaps more abundant in Texas than in Alabama, and that only full-grown worms or possibly, occasionally, a newly-formed chrysalis, are attacked. He arrived at this latter conclusion from the fact that in all the chrysalides examined which contained the full-grown parasitic larvæ the moth was already formed and its abdomen destroyed, while the young parasitic larvæ were always found in apparently healthy chrysalides where the

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moth was not yet formed. The duration of the pupa state of the Chalcis was found to be from eight to ten days in August. In issuing from the Aletia pupa it almost invariably eats a hole through the dorsal part of the thorax.[40]

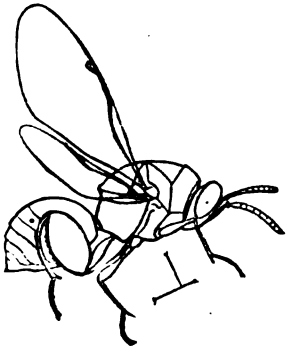

FIG. 42.—*Chalcis ovata*, female; hair-line showing natural size. (Original.)

THE DEVOURING TETRASTICHUS (*Tetrastichus esurus* Riley).[41]—The chrysalides of Aletia, formed during the latter part of the season, are frequently infested with this little parasite, each chrysalis nourishing a number which eat their way through the shell in the form of small black flies. This parasite is quite generally distributed, and has been bred in Texas, Alabama, and Georgia. The larvæ are pale, elongate, egg-like maggots, and the flies issue all through the autumn, during mild winter weather and (the later ones) in the spring. There exists a possibility that this insect is not a so-called primary parasite of Aletia, but that it infests naturally one of the large ichneumonid parasites of the Cotton Worm. This supposition is, however, contradicted by the fact that Aletia pupæ parasited by this chalcid are always found packed to overflowing with the Tetrastichus, whereas were the latter simply parasitic upon Pimpla or Chalcis, they would in all probability be found only in the abdomen of the Aletia pupa.

This parasite has also been bred from the fall broods of the worm only, which fact may be due to the possibility of its parasitism upon *Pimpla conquisitor*, or from its being, during the summer months, parasitic upon some larva other than the Cotton Worm.

SPECIES THAT ARE EASILY MISTAKEN FOR PARASITES OF ALETIA.

HEXAPLASTA ZIGZAG[42] (Figs. 43 and 44).—In September, 1879, a number of minute parasites were sent us by Professor Comstock, with the statement that they had issued from chrysalides of Aletia. The species was undescribed, and as we could place it in no known genus, we erected the genus *Didictyum*, and described the species as *D. zigzag* in the *American Entomologist*, III, 52, and also in the first edition of this Bulletin, p. 44. Later, however, we learned, through the courtesy of Mr. W. H. Patton, of Waterbury, Conn., that *Didictyum* is synonymous with the Cynipid genus *Hexaplasta* of Foerster, and published the fact in the *American Entomologist*, III, 293 (note 12). We also there expressed the belief, based on careful observation,

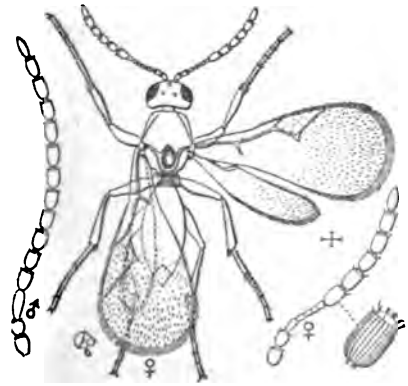

FIG. 43.—*Hexaplasta zigzag:* showing female from above, and male and female antennæ—natural size indicated in hair-line. (After Riley).

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that this parasite does not belong to Aletia, but that it in reality attacks *Phora aletiæ* Comstock—the next insect which we discuss—and that Professor Comstock was misled by appearances in considering it a true parasite of Aletia. The Hexaplasta is certainly a parasite of Phora, as the following extracts from Mr. Hubbard's notes plainly show:

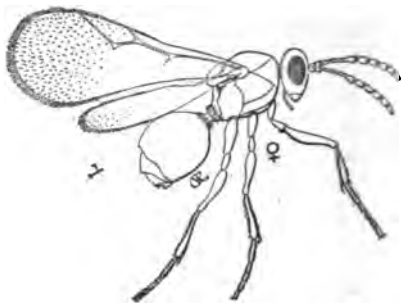

FIG. 44.—*Hexaplasta zigzag*: female from side. (After Riley).

"CENTERVILLE, *August* 21.—In one of my tin boxes, in which I keep a supply of Phora larvæ feeding upon moldy leaves, dead caterpillars, &c., I to-day observed a minute chalcid (?) fly [*H. zigzag*] puncturing one after another the bodies of a cluster of newly-hatched Phoras. I separated these maggots and the parasite. The parasite, watched under a lens, was seen to insert her ovipositor with a strong, steady motion once into the body of each larva and immediately withdraw it. The Phora larvæ were confined in a small vial with crushed Aletia pupæ for food. Examined October 13. Six parasites are seen walking about the vial. They disclosed from six Phora pupæ."

This fully confirms our own experience, and leaves no doubt that Hexaplasta is actually parasitic upon Phora, and this fact being proven it is altogether unlikely that it is also a parasite upon Aletia, although we have no absolute proof to the contrary. We introduce the account of this insect in this place, as it was considered, upon Professor Comstock's authority, under the head of the true parasites in the first edition.

PHORA ALETIÆ Comstock (Fig. 45).—Under the head of true parasites of Aletia, Professor Comstock has given detailed descriptions of a species of Phora common throughout the South, as *Phora aletiæ*, with, as it seems to us, very insufficient reasons in support of his view that it is a true parasite. These reasons were, firstly, that it had been reared in great numbers from chrysalides collected by Mr. Trelease in the field, which appeared either sound or parasited; and, secondly, that the *Ph. incrassata* of Europe is, according to Packard (*American Naturalist*, 1868), a true parasite of the hive bee.

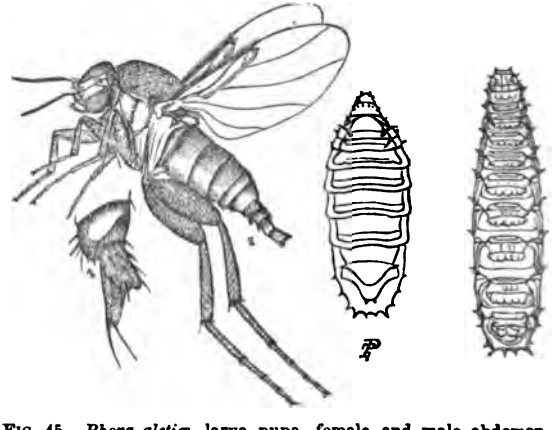

FIG. 45.—*Phora aletiæ*, larva, pupa, female, and male abdomen, highly enlarged. (Pergande *del.*)

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To answer the last argument it may be stated that *Ph. incrassata* has never been satisfactorily proven to be a bee parasite, in spite of Dr. Packard's statement to the contrary.

In regard to the first argument, our experience with this particular Phora has been quite extensive, and has proven that the eggs are laid in masses, not necessarily upon the insect, and never upon living or healthy insects. The larvæ very soon attack any decaying animal or vegetable substance; but while they may be thickly crawling about and over living larvæ, they do not penetrate the same. After the insect was considered a parasite of Aletia we took pains to have the actual facts ascertained and verified, and the observations of Messrs. Hubbard and Schwarz are conclusive. A note in the *American Entomologist*, III, 228, by Mr. Hubbard[43] to the effect that, from his observations, the flies gathered about moldy food and the excrement of larvæ, but never deposited eggs unless they found dead moths, larvæ or pupæ, and moisture, was the occasion for the following interesting letter from Baron Osten Sacken on the habits of the genus, which was published in the November (1880) number of the *American Entomologist:*

The opinion expressed by Mr. Hubbard in your September number (p. 228) about *Phora* not being a true parasite holds good, no doubt, in the majority of cases. Among the literature which I have collected on the habits of *Phora*, I find only one direct statement about larvæ of this fly having developed in a *living* insect. Mr. Brischke (Kleinere Beobachtungen über Insecten) received from a coleopterist some pupæ and imagos of *Phora*, with the remark that the pupæ had come out of the anus of a living *Osmoderma*. The friend very probably meant to say that *larvæ* had come out and had immediately transformed into pupæ. The statements of Bouché (Naturg. d. Ins., p. 101) are less direct. He obtained larvæ of *Phora* from several specimens of *Sphinx convolvuli* in captivity, and from caterpillars of a *Tinea*. Although he does not say that the Sphinxes and caterpillars were alive when the larvæ emerged from them, we are justified to assume from his wording that the larvæ of *Phora* had lived in their host, while he was alive, although they may have escaped after death. Brischke (*l. c.*) also takes it that way.

Perris, in his *Insectes du pin maritime*, had expressed the same opinion as Mr. Hubbard, that the larvæ of *Phora* are scavengers, not parasites; but later (*Résultats de quelques promenades entomologiques*, in Ann. Soc. Ent. Fr., 1873, p. 74) he confesses his doubts about the matter. He had obtained a *Phora* from the nymphæ of *Coccinella 7-punctata*, these nymphæ not showing any signs of decay. Curtis (Brit. Ent., 437) and Rondani (Atti, &c., Milano, 1860) relate similar observations. In such cases the larvæ of *Phora* may have been *carnivorous* without being *parasites;* they may have killed the nymphæ and eaten their contents. Zetterstedt's statement, "*larva* (*Phoræ*) *in Geotrupe nasicorni inventa, teste Marklin,*" may or may not refer to a case parallel to that of *Osmoderma*. The case related by Goureau (Ann. Soc. Ent. Fr., 1855, p. 21) of pupæ of *Phora*, found in a box, in which, for about a month, he had kept a pinned *Pithyrus*, is likewise not conclusive, because the *Phoræ* may have slipped in the box and laid eggs on the putrescent specimen. Still, there is enough to show, in what precedes, that there is something to be learned yet about the habits of *Phora*.—[C. R. Osten Sacken, *Heidelberg, Germany, October*, 1880.

Mr. Schwarz's observations on *Phora aletiæ* give, in good form, the habits of the species, and are herewith given in full:

"My acquaintance with this particular species of Phora dates back so far as the spring and early summer of 1875. In that year, while in

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camp near Enterprise, Fla., I was greatly annoyed by the appearance of these flies within the paper boxes where I kept the insects collected by me. These insects were killed by leaving them in the cyanide bottle for not less than 12 hours. I never noticed any Phoras in perfectly tight boxes, and they infested only such not perfectly tight boxes as contained large insects, especially Orthoptera, which in the moist air of a Florida rainy season are very difficult to dry and which were in a state of slight decomposition. The larvæ of these flies either fed externally upon the softer parts of the dead insects, or internally, and the puparia were either formed on the outside of the insects or simply fastened to any part of the box. On my second trip to Florida I had similar experience, though I was better prepared for the attacks of Phora, a liberal and frequent use of carbolic acid doing good service in keeping the flies out. Being thus familar, or at least believing myself familiar, with the habits of this Phora, I was not astonished to see it around my breeding jars and pill boxes with insects during my stay in Columbus, Tex., during the summer of 1879, and considered it as a matter of course to see the flies emerging from the jars where I kept chrysalides of Aletia, a portion of which I knew to be rotten. It never occurred to me then that this Phora would ever be considered as a parasite of Aletia. After Professor Comstock had declared it as such, I paid more attention to the insect during my stay in Selma. A number of sound Aletia chrysalides were crushed and put in a jar which was partly open. Several Phoras were seen in the jar 24 hours afterwards, and four days later the rotting mass was alive with the fly larvæ. Another lot of sound chrysalides was crushed outdoors in their webs, but only two of them were found afterwards to be infested with Phora, the others were either eaten out by the ants or simply dried up without attracting anything. Larvæ of *Phora aletiæ* were not unfrequently found in the last week of August and the first week of September in chrysalides of Aletia which hung down from the naked stems and leaf-ribs, the worms having previously utterly defoliated the plants. Many hundreds of these chrysalids which are thus unprotected from the rays of the sun or from the rain were examined by me during the time just mentioned, and by far the greatest part of them—at least three-fourths of the whole number—proved to be rotten, the contents being a light brown, badly smelling fluid. No parasitic larvæ could be discovered within, and the chrysalides showed no outward signs whatever of having been attacked by any insect. The remaining one-fourth of these chrysalides were either in healthy condition, or killed by some enemy (mostly by ants and *Podisus*), or infested with parasites (*Chalcis ovata* and *Tachina*), or contained Sarcophaga and Phora larvæ. I have to emphasize the fact that the chrysalides containing Phora larvæ contained the same rotten fluid of the same disgusting smell as the majority of the chrysalids mentioned above. From 150 specimens of such chrysalides put in a large glass jar I obtained only 5 or 6 moths, a number of the above-

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mentioned parasites, and a great many Phoras. At the same time a very large number of chrysalides were examined which had webbed up in the leaves of *Artemisia tridentata* and other weeds and shrubs adjacent to the devastated fields. Not a single rotten chrysalis was found among them, by far the largest number being healthy, and only the usual proportion contained *Chalcis* or *Tachina* larvæ or pupæ. Not one of them contained Phora larvæ, nor was any Phora raised from about 150 chrysalides which I took indoors and preserved in a tight jar. The fact that the greater portion of the chrysalides which were on the naked leaf-ribs of the devastated fields proved to be rotten, while at the same time those which had regularly webbed up in the leaves of the adjacent weeds were healthy, is probably due to the influence of sunshine and rain on the unprotected chrysalides. A large portion of these hung downward, suspended only by one thread or the remaining portion of the web. This unnatural position causes them to be stretched, the soft ligaments between the segments thus exposed offers a convenient place for the young Phora larvæ to enter the interior of the chrysalis.

"After it has once been asserted that *Phora* is a true parasite of Aletia, and since it is an undisputed fact that Phora has actually been raised from chrysalides of Aletia, it is, of course, difficult to prove the contrary. My observations prove only that Phora lives as a scavenger on other dead and decaying insects as well as in decaying chrysalids of Aletia."

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CHAPTER IX.

PREVENTIVE MEASURES.

MODE OF CULTIVATION.—Our knowledge of the natural history of Aletia and the yearly recurring experience with its ravages, teach us that the principal and most effective means of prevention is to hasten the maturity of the plant, so that a portion of the crop shall be beyond the reach of harm from the more disastrous July and August broods of the worm. The importance of this subject has long since been recognized by intelligent planters, and important results have at times been obtained. Mr. J. C. Mathews, of Crittenden's Mills, Dale County, Alabama, writes, in answer to question 15 of the circular, as follows: "We have improved our cotton seed so much that our cotton is all of a month earlier than it was when the worm first ate us up. Last season our cotton was nearly all open in August and September." Judge Jones, of Virginia Point, Tex., also writes us, September 5, 1880, as follows:

"I have been more sensibly impressed than ever before, that early planting and timely cultivation will give the cotton plant such a vigorous and early growth as to discourage the mother moth, and will materially retard their destructive movements. In nearly every instance that has fallen under my observation this season, where cotton had an early start, with faithful and diligent cultivation, the injury to the plant and its fruit has been comparatively light, or there has been entire exemption from the worm."

Improving the cotton seed in the direction just mentioned can be accomplished principally by careful selection of early maturing varieties of cotton; or by introducing seeds from more northern regions. Early planting is strongly to be urged in this connection, though, of course, it has its drawback in the risk of exceptionally late frosts. Another way to hasten the maturity of the crop has been suggested, viz., by planting the seed in hot-beds during winter, and transferring the young plants thus raised to the field when there is no longer danger of frost, on the plan adopted by Northern growers of the sweet potato.

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This same idea forcibly occurred to us on our first visit to the South; but upon suggesting it and urging it to experienced planters, they invariably replied that the cotton plant forms such a long tap-root and is so very sensitive to removal or transplanting, that the method becomes impracticable. The only way in which cotton plants could be successfully transplanted would be from small pots, and such mode is precluded on account of the expense, though paper bags, it seems to us, might in many instances be successfully used for this purpose. Careful and frequent cultivation, which, moreover, has the tendency to disturb and knock off the worms, will materially assist in producing a crop before these appear in force; and such well cultivated fields, while they are subject to the attacks very early in the season, will, at the critical period, be least injured.

Topping the cotton is recommended and practiced in some sections to hasten maturity, and while it will no doubt help to produce the desired effect, the labor necessary would hardly be repaid by the success, since it includes the loss of the top crop. Where done in order to destroy the eggs of Aletia, the labor is more or less wasted, as only a small proportion of the eggs are laid on the top leaves during the season when the chief injury is being done.

Every other means that will give the cotton plant an early and vigorous growth, *e. g.*, rich manuring, or soaking the seed, before planting, in sulphuric acid, ought to be employed, and will assist in preventing the ravages of the pest.

Taking the opposite view, Dr. Phares has suggested that by systematically deferring the planting of cotton till the end of May, or until all the hibernating moths had perished without finding food for their issue, and then planting some early-maturing variety, we might entirely prevent the injuries of the worm. This would be an excellent suggestion could the planter know beforehand that it would be necessary, and were there not decided advantages, as just set forth, in getting early maturity.

While it has been believed that the long-staple cotton is more injured by the worm than the short staple, yet the belief is by no means general, and there seems to exist no variety of cotton which, for its comparitive immunity from the attacks of the worm, deserves to be cultivated in preference to other varieties; nor have we at present any reasonable hope of producing, by careful selection of seed, a variety which is less subject to injury, a process which, if possible, would require many years to bring forth any noticeable results.

For several years past a paragraph has been going the rounds of the newspapers of the South, to the effect that a planter in Texas had produced, after many years of experiment, a "worm-proof cotton," by hybridizing cotton with a certain weed, and that he was willing to sell his secret to the Government for a handsome sum. We have not seen this "worm-proof cotton," nor can we learn that any trustworthy planter

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has ever seen it, and it is safe to put down this so-called important invention either as an illusion or as an imposition and humbug.

There are several other points in the cultivation of cotton which, though of minor importance, should be borne in mind in this connection. The frequent exemption of small fields that are separated from larger ones, or surrounded by some other crops, suggests the advisability of breaking up the very large and continuous cotton fields, and the adoption of a more diversified agriculture. It will be well, also, to avoid planting cotton in those spots where the worms have been known to first reappear from year to year. The method of interspersing the cotton with corn, often practiced in the South, may well be recommended from an economical standpoint; but less so from the entomological view, for while it may have some effect in lessening the Cotton Worm, there is not yet sufficient confirmation of the fact, and the custom doubtless helps to increase the injury from the Boll Worm.

There exists a wide-spread belief among planters that by surrounding cotton fields with certain plants, or even by planting a few such plants between the cotton rows, the latter will be protected from the ravages of the worm. This belief is evidently based on the idea that the parent moth is prevented from ovipositing on such cotton by the odor emitted by such plants.

Jute (*Corchorus capsularis*) is the most noted and familiar of these "protecting" plants. When and where the belief of the protecting power of the jute originated is difficult to prove at the present time, and the following paragraph on the subject from the *New Orleans Times* of December 25, 1873, is evidently written after this belief had already made much headway:

> It remains for us to notice the further important fact that the culture of jute in this State is likely to prove the death of the Cotton Worm. On this point we have the experience of Mr. Emile Lefranc, who assures us that neither flies nor butterflies ever stop in the jute plant. It appears the plant gives out an odor which drives them away, and the consequence is that no caterpillar will appear on the plantation where jute is grown. Desiring to verify this important and valuable discovery, the "Ramie Planting Association" last season planted three several different fields of cotton, and surrounded them with a jute growth belt. No leaf, no flower, no boll was destroyed. The fields were entirely free from the caterpillar, while other cotton fields on adjacent plantations were invaded by the voracious insects. This statement has been verified by many gentlemen of New Orleans. In the present precarious condition of cotton culture, the fact we have mentioned is assuredly worthy of the earnest attention of all intelligent planters.

How much truth there is in the verification of this "valuable discovery" we do not know, but no subsequent experiments seem to have been made and recorded, and the more recent writers on the subject, and especially Mr. J. C. Waldo, of New Orleans, who advocates this preventive measure, seem to draw only from the source quoted above. Jute is planted but very little in the South at the present time, and it was not until 1880 that one of the observers in the field, Dr. Anderson, had

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the opportunity of seeing jute planted side by side with cotton. He writes in his report as follows:

In my investigation this season I had the opportunity of seeing the jute growing in the midst of cotton. It had been planted in May, and when I saw it, late in August, had attained the height of 8 to 10 feet, and was luxuriant. The row, about 200 feet long, was surrounded by cotton, the row of the jute running parallel with the rows of cotton, and the worms were abundant on the cotton in the midst of the jute, and touching their leaves. Its effect was *nihil*.

In the fall of 1881, in the experimental grounds of the cotton exposition at Atlanta, Ga., we had an excellent opportunity of observing the effect of jute which was planted in the midst of cotton. Not only was the cotton adjacent to the jute utterly defoliated by the worms, but they had spun up in great numbers on the jute leaves.

Other plants which are believed to have similar protective influence are hemp (*Cannabis sativa*), the China tree (*Melia azedarach*), the Dill (*Anethum graveolens*), and lately the Pyrethrum plants, not to mention others which are known only under local popular names, and which we have been unable to identify. While we do not doubt that the plants just mentioned are generally free from insect injury, it is safe to say that none of them have any protective influence whatever over other plants in their neighborhood, and none whatever on the appearance or non-appearance of the Cotton Worm. Reports of success are illusory, the non-appearance of the worms being due to other causes.

PROTECTION OF NATURAL ENEMIES.—Hardly less important than early planting is the protection of those natural enemies of the Cotton Worm that permit of it. In the present state of our knowledge no practicable method presents itself that will enable the planter to protect or propagate, or in any other way encourage, on a large scale, the most effective of these enemies, viz., the parasites of Aletia; but much good can be accomplished by the protection of many other enemies, and foremost among them of the birds. The shooting and trapping of all smaller birds, which is so industriously practiced at the present time by the freedmen throughout the cotton States, as well as the collecting and destroying of birds' nests and eggs, should be prohibited, while the killing of hawks and other birds of prey should be encouraged. Tame fowls, such as chickens, turkeys, and guinea-hens, have proved valuable in protecting small fields near the house, and would accomplish much good if brought up near those spots where the first worms occur.

Lizards, frogs, and toads, which are familiar objects to every one, and a great many of the insect enemies of Aletia, *e. g.*, Ground-beetles, Soldier-beetles, Lady-birds and Soldier-bugs, which by their size or coloration are conspicuous enough to be recognized by the planter from the figures given in the chapter on Natural Enemies, should never be wantonly destroyed. The leaving of an occasional stump in the field is, we believe, advisable, because the nests of ants in the ground are less liable to be washed away and destroyed by rains in fields where trees and stumps occur.

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Where hand-picking is followed, the pupæ should not be crushed at once, but placed in a barrel covered with a wire screen to admit of the escape of the parasites, and at the same time to retain the moths and cause them to perish.

IMMUNITY OF COTTON UNDER TREES.—The immunity of cotton growing under single trees that are left standing in the field has long been noticed and attributed to the protection and attraction afforded to birds by such trees. We had adopted this view in the first edition of this work, but the great regularity with which this phenomenon occurs throughout the cotton belt, and several other circumstances connected with it and presently to be mentioned, induced us to have the subject re-examined. There is no doubt in our mind that this exemption of cotton is due to the direct influence of the tree on the plants growing under it, and not to the birds and other enemies of the worm.

Mr. J. P. Stelle, during his stay in Texas, conducted an experiment which throws some light on the subject, and which he records in his diary as follows:

August 30, 1881. It is thought by all planters that shade protects cotton from the work of the Cotton Worm, and it grows out of the fact that plants growing under trees are more or less exempt. I have attributed the exemption to the work of birds; but the planters declare it to be shade. To settle the question I have to-day erected a temporary shed over a number of plants by stretching an old tarpaulin above them, on stakes in the center of a field.

September 3. My temporary shade has proven a protection to the plants; the worms are not working under it to amount to much, though all around they have completely stripped the cotton.

Other observations show that cotton growing under a dense tree is not only exempt from injury, but even not touched by the starving and migrating worms. This fact alone indicates that the presence of birds cannot be the true explanation. It has been further observed that a small tree, or a dead one, even if it has many branches, has but little protective influence, or none at all, on the plants growing under it. That this influence cannot be entirely due to the shade alone appears more than probable, since it is exerted on all sides of the tree. Whatever the real cause may be that prevents the work of the worm under such circumstances, it likewise affects the cotton injuriously, for on poor soil such cotton remains very poor and small, while on rich soil it grows rank, and consequently bears very few bolls or none at all. There is no way of making any practical use of this influence of trees on the work of the worm.

PREVENTING OVIPOSITION OF THE MOTH.—As a possible means of prevention, the idea suggested itself to apply some substance to the plants which, by its odor or otherwise, would drive off the moths, and thus prevent oviposition. This idea opens, of course, a large field for experimentation; but we confess that, for several reasons, we do not hope for important results in this direction. The few experiments that have been made are far from being encouraging, and are simply re-

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corded here to show that this suggestion, which, theoretically, looks plausible enough, is practically beset with great difficulties. We quote the following paragraph from Mr. Schwarz's report on experiments made at Selma, Ala.:

While experimenting with decoctions and extracts of various plants, and knowing that the moths were ovipositing at the time, I tried the following three substances, with a view to ascertain whether they rendered the plant sufficiently distasteful to the moth to prevent her from ovipositing: 1. Infusion of Ailanthus leaves; 2. infusion of Walnut leaves; 3 decoction of Hoarhound. The first I selected without any special reason, being influenced only by the universal belief in its efficacy; the second because I knew by experience that it rendered the leaves distasteful to the worms; the third, on account of its most powerful and unpleasant smell.

The application of the three substances was made very easily, as the moths oviposited at this time (September 5) with preference on the leaves of the young shoots arising from near the roots of the plants. Three small shoots, each on a different plant, were then examined for eggs, and, after removing these with a knife, the infusions were plentifully applied so that each leaf was fairly drenched from both sides. (Selma, Ala., Sept. 5.)

Examination on the 7th of September shows that none of my decoctions had the slightest effect, the number of eggs laid on the three shoots being quite considerable, and apparently not less than on other shoots not treated with any substance. There was a heavy shower yesterday, but the leaves being sprinkled on both sides, the rain could not have washed away every trace of the decoctions.

Observations in the field seem to show that common road dust could possibly be utilized to prevent oviposition of the moth. Mr. Stelle says, in one of his letters from Calvert, Tex.:

A much traveled road runs east and west through the field; on the south side of it the cotton is badly eaten by worms, while for 40 feet along the north side it does not seem to have been much disturbed. I investigated for the cause of this exemption, and found it to be the result of a south wind blowing the dust stirred up in the road over the plants. It seemed to have at least retarded the work of both Boll and Cotton Worms.

Mr. Schwarz, while speaking of those spots in cotton fields which had escaped the general destruction by the worm in August, 1880, says:

The outside row or rows of a field are very often exempt, sometimes even to a remarkable degree, but by no means always. In some instances this immunity may be due to the direct influence of the road dust that thickly covers the leaves, but it occurs also where there is no road, and consequently no road dust, and where, therefore, another explanation is necessary. I fail to find any satisfactory explanation, unless, perhaps, in such cases the outside rows grow under conditions less favorable to the plants, which thus have less attraction to the moth.

Mr. Stelle himself noticed later the exemption of the outside rows of cotton fields. He writes in his diary, September 3, 1880:

I have noticed in fields that the plants growing adjacent to open spaces, as along roads, even though but little traveled, are more or less exempt from the working of the worms. In the midst is about one-fourth of an acre in sweet potatoes, rank-growing and clear of weeds. For about the width of two rows around the patch the cotton is scarcely touched, while everywhere else it is completely trimmed.

I have seen a similar case along the side of a patch of peas (Dolichos) where the exempt rows were several hundred yards in length.

Similar facts have often come under our notice and are quite commonly observed.

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Some experiments with road dust, but more with a view to drive the worms off, were carried on and will be recorded later. It suffices to state here that the results obtained render it highly probable that a thick coating of dust not only protects the plants from worms but would also prevent oviposition of the moth. There is also but little doubt that flour, ashes, in short every pulverized material that can be made to adhere thickly to the plant, and especially to the underside of the leaves, could be substituted for road dust.

EARLY APPLICATION OF DIRECT REMEDIES.—As preventive measures we must further consider the early application of the direct remedies, in other words, every attempt to destroy the insect early in the season before it is numerous enough to do much injury. The remedies themselves will be discussed later on; it suffices to say that we have to deal here with the destruction of the hibernating moths, or those of the first generations, and the poisoning of the first worms. The importance of either method is too apparent to need further advocating, but the apparent advantage disappears to a large extent upon practical consideration. The gravest obstacle is that the concerted action of the planters over an extended area is necessary to insure a decided success in the early application of direct remedies, the work of the individual planter, or even of the majority of them, being more or less frustrated if a portion remain passive.

Without suitable laws to enforce concerted action, there is but little prospect of making much headway in the general adoption of preventive measures of this character. Still the individual planter would do well not to omit any opportunity to destroy either the first moths, or the first worms.

Poisoned sweets should be placed at suitable localities on warm evenings during the earliest part of the season, say from the beginning of February till the middle of April. With each female moth caught in this way the planter might save a great deal of the expense in poisoning the worms; and not only could Aletia moths be destroyed in this way, but also other hibernating moths, a great many of which are the parents of destructive Cut-worms. The poisoning of the first worms requires knowledge of places, usually limited in extent, where they occur, and this is not always easily obtained in large fields. The field-hands should be instructed to watch carefully, while cultivating the field, for evidence of the work of the first worms, and when such places are discovered the application of poison should never be neglected. The poisoning of limited areas where the first worms occur requires but little outlay of time and money. The children should be made thoroughly familiar with the appearance of the worm and its work, and should be sent over the field at least once a week during the months of April and May in order to discover the places where the first worms occur. The worms could then easily be destroyed by hand-picking or by immediate application of poison.

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A general poisoning in advance of the first appearance of the worms has been recommended, but it is evident that there is little to be gained by this method, first, on account of the rapidity with which a new growth of leaves is made thus early in the season; secondly, because the poison would be washed away after the lapse of one or two weeks, and much earlier in unfavorable weather; and, thirdly, because it is an unnecessary expense, since the first worms appear only in isolated spots, which may be discovered by careful watching.

COTTON WORM WARNINGS.—In the more northern portions of the cotton belt the worm appears only after it has multiplied or been very bad in one or several places in the more southern portion. The importance to the more northern planter of keeping posted as to the progress of the worm in the hibernating centers is, therefore, evident, as he will thus be enabled to provide beforehand the means of destroying the pest. To provide for and keep up such Cotton Worm signals and warnings is a very easy matter when compared with the Locust warnings in the West. The permanent region of the Locust is the least accessible and least populous region of the country, while that of the Cotton Worm is the richest and most densely populated portion of the South, traversed by numerous railroads and telegraphs, with populous cities and an enterprising press.

As a measure intended to reduce the number of hibernating moths, it may be suggested that, as vast numbers of late chrysalides are usually carried into the gin-house, and as the moths issuing therefrom are so likely to find the requisite winter protection there, the expediency of removing and destroying these chrysalides as soon as possible, and of not allowing them to remain in the gin-house until they hatch, is apparent.

FALSE THEORIES.—There is, of course, no want of theories regarding preventive measures, mostly based upon wrong conception of the natural history of the insect; nevertheless, they always find advocates. One of these proposed measures is to burn, in winter time, the old stalks of the cotton plants, instead, as is generally done now, of breaking them down in the spring, the intention being to kill the insect supposed to be hibernating within the stalks. Another measure frequently recommended is to plow the fields in winter time in order to expose the chrysalides, supposed to be in the ground, to the rain and frost. The premises being false, the theories with their suggestions are worthless.

Another widely disseminated notion prevails as to the preventive power of salt sown on the field while planting cotton, or even after the plants are up. This method has been tried by reliable planters, and, as might have been foreseen, with indifferent results, the rows where salt had been used being no less injured by the worms than the rows not salted. That salt has a beneficial influence as manure in certain kinds of soils there can be no doubt, but its supposed protective influence is wholly imaginary, being based on the vague notion that the salt is absorbed by the plant, which is thus rendered distasteful to the worm.

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CHAPTER X.

REMEDIES: MEANS OF COPING WITH THE INSECT: SUBSTANCES USED FOR ITS DESTRUCTION.

In this chapter we shall treat of remedies against the insect, but more particularly of methods and principles and of substances that may be used for its destruction. Mechanical contrivances and machinery for the proper application of the remedies will be considered in subsequent chapters; for while it is not always easy to discuss a remedy without including the means of its application, yet this classification of the matter of the report has been found most expedient.

DESTRUCTION OF THE EGGS, CHRYSALIDES AND MOTHS.

DESTRUCTION OF THE EGGS.—The exact knowledge of the natural history of any injurious insect enables us to recognize its vulnerable points, and to indicate those stages in which it may be dealt with most effectively and most economically. The eggs being laid singly on the under side of the leaves, and being, moreover, hardly perceptible, from their small size and protective color, it is at once apparent that every attempt to mechanically destroy them in large numbers must be fruitless. Topping the cotton, as a means of destroying the eggs, is, as we have already shown, of little avail at the most critical period. Experience has shown that the vitality of the egg is not destroyed by the application of a moderate quantity of insecticides of any description. Mr. Stelle reports that "London purple has destroyed and prevented the hatching of the Aletia eggs" to which it was applied three days previously, and numerous experiments proved that kerosene also, when brought in contact with the egg, will destroy it. However, in order to destroy the egg, both London purple and kerosene have to be applied in such quantities as to be injurious to the plant.

DESTRUCTION OF THE CHRYSALIDES.—The chrysalis of Aletia, more or less perfectly protected by leaf and web, affords little chance for its successful destruction. The destruction by crushing or otherwise of any chrysalides observed early in the season ought not to be neglected, but later in the season, when they abound, they cannot thus be economically destroyed. There are, however, periods when the extensive destruction of the chrysalides would seem practicable. Whenever a field of cotton has been defoliated, the worms web up thickly in the surrounding weeds and brush, which may then be cut and burned. This

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mode of destruction would be of no special or immediate benefit to the planter who undertakes it, but if done generally in the district defoliated by the worms, it would help to prevent the emigration of the moths to other regions, or if done late in the season it would lessen the number of hibernating moths.

DESTRUCTION OF THE MOTH.—Easy as it may seem to prevent the mischief done by the worms, by trapping or otherwise killing the parent moth, and notwithstanding the fact that one method of attracting them has been known and used for very many years, and that another method of doing so has been more recently discovered, yet the results that have followed the attempts to destroy or exterminate the moths by these methods are not, as a rule, encouraging. The unsatisfactory results may be attributed to, *first*, lack of concerted action; and, *second*, delayed attempts to kill until the moths had already become too numerous and the worms had done considerable damage.

It has already been remarked, with regard to the first point, that concerted action over the whole cotton-growing country cannot be expected; but if the planters in those more or less limited districts that are known as the distributing centers of the insect, or even in those particular spots where the worms appear and reappear year after year, would make earnest effort, at the right time, to trap and kill the moths, there is little doubt but that the excessive increase of the insect would be either retarded or prevented. If this pest is suffered to increase until the third or fourth generation, any attempt to lessen the number of worms by killing the moths will necessarily prove futile. To make this method of preventing injury of any avail, action must be taken *early* in the season."

Lights for attracting the Moth.—That the moth is attracted by light is an old and well-known fact, and in the days of slavery the only remedy generally used by planters, besides the hand-picking of the worms, was to light large fires in, or have burning torches carried through, the fields at night. It is impossible to say at the present time whether or not these efforts were successful, but it remains a certainty that in "worm years" the progress of the ravages was never prevented by such means. It is almost needless to remark that in those days, as in the present, such means were generally resorted to when the moths had become quite numerous, and when, therefore, no success was to be expected.

Special fires intended for this purpose were generally made of dry wood placed upon earth elevated on platforms. While for the reasons here given we have little faith in the utility of such means at any other season than early spring, yet the practice of cleaning the fields of all rubbish and old stalks by making large bonfires in winter—a practice that prevailed before the war, but which has been largely abandoned since—is greatly to be commended on general grounds.

It has been found troublesome, and, in some parts of the country, even

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expensive, to keep up large fires during the whole or greater part of the night; and during the last decade a great many lamps have been invented to take the place of fires. A lamp is more effective in attracting the moths than is a large open fire; for the heat and smoke of the latter scare away great numbers. Where lamps are employed there must be connected with them devices to kill the moths that are attracted by the light, and such killing is best accomplished by placing the lamps in pans filled with various substances of a sticky or destructive nature.

During the earlier part of the summer of 1879 extensive experiments were made by Mr. Schwarz at Columbus, Tex., to test the efficacy of lamps. Though it was already too late in the season to check the increase of the insect, some of the results are not without interest. The number of moths nightly killed by a single lamp varied very much according to its location, but averaged not more than six specimens in the latter part of June, the number increasing rapidly during the next month. It was also found that these lamps attract and kill an immense number of other insects. Among these are many injurious insects, as *Heliothis armigera* (the parent of the Boll Worm), which, by the way, appears to be more readily attracted than the Cotton Moth, and several species of May-beetles (*Lachnosterna*) and others; but also, unfortunately, large numbers of the natural enemies of the Cotton Worm, as the nocturnal Tiger-beetles, Ground-beetles, and some of the Heteroptera already mentioned. Above all, it was found that the moths were not prevented from ovipositing even in the immediate vicinity of the lamps, and that on the fields where the lamps had been used there were no less eggs deposited than on those where no lamps had been kept burning. It becomes questionable, therefore, whether the lamps are not more productive of harm than good, especially at times when the moths are numerous. However, if, as is doubtless the case, the hibernating moths fly about early in the spring, then this will be the best time to use lamps in places where the moths have been seen flying, as in the vicinity of gin-houses, &c. In the month of March and in the earlier part of April they should be placed at those spots in the fields where the first worms have been observed in previous years.

During the month of March, 1882, we instructed Mr. Koebele, then at Archer, Fla., to try on several successive nights to attract the moths by lights. Though freshly deposited eggs were constantly found at this season, and it was certain, therefore, that the hibernated moths were flying about, yet not a single specimen was attracted by the lamps. This result is certainly not encouraging, but it must be remembered that success in this method of collecting largely depends on locality, on the state of weather, and on other conditions.

Experiments made under our direction have proved that during moonlight nights fires or lamps have but little attraction for the moths, and, further, that better results are obtained before than after midnight.

The only instance with which we are familiar where lamps (those made

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by Colonel Lewis and described in Chapter XIII) have been used on a sufficiently large scale to fully test the efficacy is that around Hearne, Tex., in 1878. Over 1,000 lamps were used in that vicinity during a period of several weeks, and while it was true that cotton was not injured that year, the same was equally true throughout that whole section of the country; so that it was impossible to draw any satisfactory conclusions. Still, where they were used pretty extensively in 1879 they did not prevent final injury to the cotton, and where but a few are used in some particular fields, it is undoubtedly true, and in accordance with general experience, that more harm than good ensues to the individual using them—the moths being allured from other fields and frequently laying their eggs before perishing. The worms are, consequently, often more numerous at such centers than elsewhere.

At the Atlanta Exposition Hotel, in the autumn of 1881, these moths swarmed in myriads about the electric lights outside of the building. Beneath these the ground was strewn with dead moths, and a quart of them would often accumulate during a single night in the glass globe surrounding each light. It is to be inferred that the more brilliant the light is the farther will it attract, and the less heat it exhibits the closer will the moth approach. On these accounts electric lights may be the best, and probably the calcium lights and gaslights will rank next; but at present these are generally not economically applicable for field use. In general a kerosene lantern will be found most convenient.

The whitish flames give as good results as, and probably better results than, colored flames. There is not satisfactory evidence that these insects take cognizance of the qualities of the light, but its degree of intensity seems to be a more important consideration. Movement of the light has long been recognized as enhancing the chances of capture. These facts came to light with the practice of carrying torches between the rows and at the same time agitating the plants. In Louisiana and Arkansas we were informed that parties of several persons abreast have gone through the fields in this way, and claimed that the moths were thus successfully destroyed. Probably this method was observed also in Texas, as the portable lamp or torch machines of Le Blanc and Fordtran appear as though they might have been suggested by it. The nocturnal labor and the machinery required prevent these methods from becoming popular.

The various kinds of trap lanterns which have been invented will be described and figured in Chapter XIII.

Poisoned Sweets and Fluids as Means of destroying the Moths.—It has long been known that the Cotton Moth, like most of the other species of its family, has a great fondness for sweets. Southern writers upon the insect repeatedly mention the fact that the moth is numerously attracted by barrels or other vessels containing molasses, by sugar-vats, &c.; while, as we have already seen (p. 11), it is very fond of most ripe fruits. The second peach-crop very often suffers materially from the

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attacks of these moths, as, by means of the spinous tip of their tongue, they literally work through the skin, suck out the juices, and excavate large holes. Figs and melons are often injured in the same way; indeed, it is almost impossible to raise some of the finer varieties of figs if these moths are abundant.

There was some hope of beneficial results being obtained by using baits that would prove at the same time attractive and destructive to the moths, since, if we kill the parents, we prevent the injury by their progeny. Taking advantage of the fondness of the moths for sweet substances, many planters have been in the habit of breaking open ripe watermelons, sprinkling them with Paris green or arsenic, and depositing them in cotton fields. Very good results have followed, so far as the destruction of the moths is concerned; and it is a little surprising, viewed with the preconceived notions of entomologists, that comparatively coarse substances like these minerals should be sucked up through the proboscis.

A number of experiments, with a view of testing the most attractive as well as the most deadly substances, have been made in various parts of the cotton belt during the past few years under our direction. Ripe peaches dusted with arsenic or drenched with a solution of arsenic and dried peaches moistened with water and poisoned in the same way, were placed in boxes on the ground in the fields. On examining the boxes the next morning, several dead moths were found in those containing the fresh peaches, but none in those with the dried ones. Experiments with a mixture of molasses and rum, or vinegar, or beer, poisoned with a small quantity of arsenic, Paris green, London purple, or cyanide of potassium, and smeared on the trunks of trees, or on fence poles near cotton fields, or again on the leaves of the plants, also proved that a number of moths may be killed in this way, though it is difficult, if not impossible, to get at the exact number, since many fly away before dying. The mixture of molasses and beer seems to have the greatest attractiveness, and the virtue of all these mixtures for this purpose may be enhanced by the addition of the essence or flavoring extracts of certain fruits, as peaches and apples. None of these mixtures are as attractive, however, as the fruits themselves, or even as watermelons.

The liquids may be employed not only by smearing in the manner set forth, but also in shallow tin pans or vessels placed in the fields upon pedestals, as in the case of the lamps to be described. Where such pans or other vessels are used there should be a wooden lattice-work made to float on the liquid, so that the moths may reach it without drowning, and thus be able to get away to perish elsewhere and make room for others. These liquids are frequently used in wide-mouthed bottles distributed over the fields. One general rule should be observed in the employment of these liquids and poisons. It is that they be placed in the field only about sunset, and not allowed to remain during the day; otherwise, more beneficial than injurious insects are actually

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allured. The smearing has the advantage over the use in pans and bottles, in that fewer beneficial insects are destroyed.

We cannot say that these experiments have led us to be in any way sanguine of substantial benefit flowing from this mode of killing the moths in the autumn, which is the season when they are most easily so destroyed, for they do not seem to care much for such baits except when they cannot get their more natural food in the shape of saccharine exudations. The fact that early or summer ripening peaches are not injured—a fact that is well attested by many correspondents—also indicates that the moths do not care so much for fruits even, so long as they can obtain nourishment in the cotton fields, and so long as they are not congregating in numbers.

Experiments made in the summer season with these artificial baits indicate that a much smaller percentage of moths is allured thereto, and while there can be no question of our ability to kill a certain number in this manner, it would prove a most expensive remedy if used on a sufficiently large scale to materially reduce their numbers. In fact, we have become convinced that there is very little use in attempting to destroy the parent moth in the latter part of the season. In what has been previously said on the natural history and the hibernation of the species, it has been made pretty clear that the great bulk of the moths are naturally destined to perish in any event, so that the labor is largely thrown away.

Until, therefore, we discover some baits that shall have a greater attraction for the moths than the natural sweets they feed upon, there is little to expect from this mode of warfare. There is a season, however, when the use of these baits is strongly to be recommended, and, oddly enough, it is the season when nobody thinks of using them. It is in this as it is with the lights; the greatest good will result from attracting and destroying the first moths in spring after they issue from their winter quarters. Every female killed at that season is equivalent to the destruction of several hundred worms later in the season; whereas not one in a thousand, and perhaps not one in a hundred thousand, of the Moths killed in autumn would, in the natural course of events, have survived to beget progeny. Concerted action is just as necessary here as in the use of lamps.

As it has been proven beyond doubt that sweets poisoned with Paris green or London purple do not lose their attractive power to the moth, and that such poisons are taken up by the moth, it appeared most desirable to poison the glands on the cotton plant, which, as we have seen, furnish, with their saccharine secretion, one of the principal food supplies of the moth. Experiments on plants covered with netting, and others kept in breeding cages, made it certain that the moth can be killed by poisoning the under side of the leaves, the moths feeding on the poisoned glands. So long, however, as there were no means known to apply the poison from below, this plan could not be adopted; but,

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as the perfected machines supply this want, we may justly expect that the efficacy of the arsenical poisons is considerably increased by the destruction of many Moths before these have deposited their eggs.

Finally, in this connection, we would mention a theory or proposed remedy by Dr. J. Lupton, of Winchester, Frederick County, Virginia. Noticing that the Bee Moth was more attracted to a fluid sweetened and flavored from the hive than to any other kind, he conceived the idea that the Cotton Moth would also be most attracted by sweetened water which was flavored with the bruised leaves of the cotton plant. Prof. N. T. Lupton, of Vanderbilt University, Nashville, made an experiment in 1872 which seemed to indicate that the liquid thus prepared with cotton leaves had the greater attractiveness for the moth as compared with ordinary molasses and water, and being anxious to decide the question we took pains to have the proposed remedy fully tried.

We quote from Mr. Schwarz's report the following account of experiments made by Mr. Patton and himself at Selma on the attractive power of the cotton-leaf essence:

In accordance with your instructions, I gathered, while at Selma, Ala., a quantity of fresh cotton leaves. From about 8 pounds of these leaves one pound of alcoholic extract was obtained, and from another lot of leaves a simple decoction was made.

During the first week of October there appeared to be a good opportunity for experimenting, as the evenings were warm again (after a preceding cold spell), and as the moths began to hatch. On October 8 and 9 I "sugared," in company of Mr. Wm. H. Patton, a number of trees, fence boards, and posts, in a favorable locality, with the following substances:

1. Mixture of molasses and beer.
2. Mixture of molasses and extract of cotton leaves.
3. Extract of cotton leaves alone.

Care was taken to apply each mixture on equally favorable places, or at least on places which appeared to us equally favorable. The result was as follows: A very large number of Noctuidæ was attracted, especially on the first evening, when there was no wind, but Aletia was by no means the most numerous species among them, being the third in rank.

The places sugared with No. 3 proved decidedly less attractive than the others, and only a few moths of all species were found at them. The probable reason thereof is that the extract evaporates too quickly without addition of a sticky substance. At the places sugared with Nos. 1 and 2, 70 Aletias were captured, 50 on the first, and 20 on the second evening. The latter were just equally divided between mixtures 1 and 2, but of the 50 Moths on the first evening there was a decided difference in favor of mixture No. 2, 30 Moths being found attracted by the molasses and cotton-leaf extract, and only 20 by molasses and beer. There were 12 places sugared with Nos. 1 and 2, six with each mixture. Four of these proved to be not attractive at all to the moths, the remaining being more or less attractive. But one fence-post, sugared with No. 2, proved, by far, more attractive than the rest, and it was this spot alone which made the difference in favor of No. 2, the number of moths collected on the other places being remarkably equal. I have no doubt that had this fence-post been sugared with No. 1 the difference would have been in favor of No. 1. My opinion, therefore, is that the attractiveness of sweets is not increased by the addition of cotton-leaf extract, and that such extract alone has, to say the least, not a greater attractive power than other sweets.

I intended to test the cotton-leaf decoction on one of the next evenings, but the weather continued to be cold until my departure from Selma.

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That decoctions or extracts from cotton leaves should prove attractive to the moths was to be expected, since they contain a great deal of saccharine matter; but from the comparative experiment quoted above and from the established fact that the moth is indiscriminately attracted by all sorts of sweets, we are constrained to believe that Mr. Lupton's theory has no more practical value than the other plans mentioned above to attract the moth.

From the experience gained since the beginning of this Cotton Worm investigation we have come to the conclusion that of the two methods to kill the moth, that of alluring it to poisoned sweets appears by far preferable to any of the lamp traps that have been recommended. In combating this pest it would be unwise, however, to rely solely upon any attempt to kill the moth. The principal effort of the planters should be directed toward killing the worms; yet, considering the cheapness and effectiveness of killing the moths by poisonous sweets, any judicious and timely attempt in this direction is well worth trying. Whether or not the hibernating moths can be attracted to poisoned sweets during mild evenings, in winter or early spring, we are not prepared to say. There has not been much opportunity to settle this question by continuous experiments made at the right place and at the right season, and from the failure of a few isolated attempts it would be unjust and premature to draw general conclusions.

The recommendation to use white rags in the field has frequently been made in the Southern papers, on the supposition that the female moth is attracted to such rags and will lay her eggs thereon. We know not how this idea originated, but so far as we are able to learn it is one of the many fallacies that have prevailed regarding the habits of the insect.

MECHANICAL MEANS OF KILLING THE WORMS.

Even in a very thickly settled country, and with the employment of hundreds of hands, it would be next to impossible to save, in the height of the season, a large cotton-field from destruction by simply collecting the worms. In our Southern States, where field labor is at present by no means abundant, picking off the worms when they are in destructive force in large fields is out of question, and can be profitably resorted to only on small patches favorably situated. Yet it is comparatively easy and requires but little time and a small force to thus destroy the worms of the first generation, though it cannot be denied that poisoning the places where the first worms have been observed would be far more safe and economical than hand-picking. If, therefore, the planter care to stimulate the efforts of children or field hands to find the first worms by offering some reward, it should be given for the discovery of the spot where the worms occur, and not for the capture of every worm up to a certain date.

It has been proven by experience that every means by which the

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worms can be disturbed and knocked down or brushed off from the plants has, to some extent, a beneficial influence in lessening the number of the worms, the explanation being that once on the ground they can be crushed in some way or that they are very liable to the attacks of the ants. In very hot and dry weather the knocked-off worms are very often unable to regain the plant, and perish on the hot soil. Thus, frequent cultivating and working of the cotton will have some beneficial effect in this regard, and a number of contrivances have been suggested to expedite this mechanical method of killing the worms. One of the best, in the words of Dr. J. D. Hoyt, of Livingston, Ala.,* "is to drag something like a piece of cotton-bagging along over the rows of cotton, forward and back, which may be long enough to extend across several rows, and having short lines attached to one edge, a little further apart than the width of the rows, and a hand at each line, and all abreast pass along between the rows, and then back; when the brushing and shaking of the stalks by the bagging will clear the cotton mostly of the worms. In this way a set of hands can go over their crop in a day or two, when they should return to the beginning and go over again, and continue so doing as long as any number of worms are found on the stalks." At best, however, only a portion of the worms are knocked off, for no amount of shaking or brushing, even when violent enough to injure the plants and knock off the bolls, will dislodge all the worms, and particularly will not disturb most of the young ones.

As this subject will, however, be treated of in its proper place in Chapter XIII, we will pass at once to the consideration of the substances which may be employed against the worm.

POISONING THE WORMS.

MINERAL INSECTICIDES.

With the introduction of mineral poisons for the destruction of the worms a new impetus was given to the invention of machines and contrivances for the application of these poisons either as powder or in water. The large number of such inventions that have been perfected, and the activity still displayed in adding improvements, furnish evidence that this poisoning of the worms has so far proved most satisfactory in protecting the crop. The fact is that a judicious and timely application of the best poison will always, even under unfavorable conditions and in bad "worm years," enable the energetic planter to save at least the larger portion of his crop.

The progress in improving the quality of the insecticides already in use, and the discovery of new and more effectual ones, is slower than the invention and improvement of machinery, because of the numerous difficulties in thoroughly testing any remedy in the field, the most serious being the great susceptibility of the cotton plant to injury by some of

* Practical Modes of Destroying the Cotton Worm; A Prize Essay. Selma, Ala., 1874.

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the most effective insecticides. Still, considerable progress has been made since the investigation began. The improvements and discoveries will not only greatly benefit the cotton-planter, but the agriculturist in all parts of the country, since many of the discoveries are of general application to most of our leaf-eating insects.

The most important point to be insisted upon is, that the planter in the southern portion of the belt should consider the poisoning of the worms as inseparably connected with and part of the cultivation of cotton. So many days' labor in the year, and a certain expenditure of money to purchase, prepare, and apply the poisons, and to buy and keep in repair the requisite machinery, are inevitable. In a very favorable season the poisoning, it is true, may not be necessary, but experience very plainly indicates that no year now passes when the worm is not injurious in some part of the cotton belt. Cases of complete or comparative immunity occur almost every year even in the hibernating portion of the cotton belt, but as they depend on locally restricted conditions, the planters ought never to rely upon them. It ought never to be forgotten that labor and money expended in a judicious application of poison are always amply repaid by a corresponding increase of crop.

The various insecticides now be considered are divisible into two classes: first, those which act through the stomach—the arsenical poisons, and some allied ones; secondly, those which kill the worm upon actual contact, such as oily substances and pyrethrum. A vast number of other substances cannot at present be brought under these two heads, as they are still in the experimental stage, and many of them will, no doubt, upon further experimentation, be altogether rejected as of little or no value. The action of the poisons of the second class is immediate, but not lasting, the substances being more or less volatile; whereas the poisons of the first class have no immediate effect, but their action is lasting.

This difference in character requires some modifications in the practical application. The greater the adhesiveness given to the poisons of the first class, without injury to the plant, the better; while in the poisons of the second class no such precaution is necessary. The use of arsenical poisons has the advantage that only the enemies of the plants are killed directly, though the killing of birds and other enemies of the worm, by eating it when poisoned, has occasionally been reported. Those insecticides that affect by contact, on the other hand, kill friend and foe alike. Other relative advantages and disadvantages will be pointed out further on.

It is very evident, from the habits of the worms, as already detailed, that the poisons of either class will prove most satisfactory if applied to the under side of the leaves; and, as we shall see in the chapter devoted to it, the recently invented machinery overcomes the obstacles which were formerly in the way of such application. The importance of an early application of poison has already (p. 126) been pointed out.

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Finally, too much stress cannot be laid on the importance of having the materials ready, prepared in advance, or on their use as soon as the eggs or young worms are noticed. It is too often the habit to wait until the plants begin to be "ragged" before attempting to poison. The operation is always more costly and unsatisfactory at this period, and there is danger that, with the most strenuous efforts, irreparable damage will be done before all the cotton is gone over. It often happens, also, since the same influences cause the multiplication of the worms over pretty large areas, that a sudden and general demand for the poisons by those who have not previously laid in a stock increases the price or exhausts the market, so that many are left without hope of saving their crop.

ARSENICAL COMPOUNDS.

Arsenical compounds have the acknowledged disadvantage of being dangerous to man and beast. Some writers, taking a most narrow and theoretical view of the subject, bitterly object to their use on the score of their dangerous character, exaggerating in their enthusiasm the injury that has resulted from their use. Not only hundreds of tons, but thousands of tons of these mineral poisons have been employed during the past decade by farmers throughout the country, whether to protect the potato crop, or the cotton crop, or other products of the soil from the ruinous attacks of insects. The general experience during this long period and over the whole country is so emphatically in favor of their use and their perfect safety and harmlessness, with ordinary precautions, as to render almost laughable the objections of the few persons referred to. No advancement, no improvement, no general benefit to the human race is ever accomplished without some attendant danger, and those who inveigh against such improvements as increasing the risks to life stand on the same footing as the opponents to arsenical poisons as insecticides. It is a noteworthy fact that, since we have been pursuing this cotton-insect investigation, not a single fatal case of human poisoning by the use of these minerals against the worm has come to our notice from the South, notwithstanding they are often used in that section of the country with great recklessness. Nevertheless, it is no uncommon thing to hear of partial poisoning among negroes, resulting from that indifference which comes from constant use, and the importance of care and caution cannot be too strongly urged, especially near towns or in thickly settled neighborhoods.[45]

None of the correspondents of the Commission report serious injury to man by arsenical poison in its application for the Cotton Worm, and only one of them reports directly a case of poisoning a horse; all others report such cases from hearsay.

It has been our principal ambition to discover some substitute for these poisons that shall be equally effectual, harmless to man, and cheaper. The experiments that have been carried on by the Commission with this object have been sufficiently encouraging, as the sequence

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will show. In fact, we do not doubt that arsenical poisons will in time be superseded by insecticides that are harmless to man, but as matters stand, the cheapest and most satisfactory remedy has been found in the application of certain arsenical poisons. Another disadvantage of arsenical poisons should be borne in mind, viz., the susceptibility of the cotton plant to their caustic action, the leaves being more or less blistered or burnt by an overdose, while leaves, blossoms, squares, and even young bolls may be killed by an excess; so that they are valuable, *cæteris paribus*, in proportion as they are harmless to the plant.

We cannot give in simple numbers the minimum quantity of any of these arsenical poisons to be applied with safety to the plant, and at the same time with the desired effect on the worms. This is due to the lack of unity in the application and consequent unequal amounts of poisoned mixtures distributed per acre. If, *e. g.*, by one machine 50 gallons of a given mixture are distributed over one acre, while by another only 10 gallons are needed over the same area, it is evident that the minimum quantities of poison required per gallon cannot be the same in both cases. Further, the size of the plants, the width of the rows, the state of the weather, the character of the admixtures used, all have an influence in determining the minimum quantity.

The figures given below must therefore be considered as the average, derived partly from trustworthy experiments which we have made, partly from the rates which are locally adopted and which have proved satisfactory by long practice, but which differ widely in different parts of the country. It is to be hoped that with the general adoption of the most improved machines, which distribute the mixtures most economically, a more uniform rate can be established.

The question has been raised lately whether a certain amount of scorching by arsenical poisons is really so injurious to the plant as is generally believed, or to put the question in its extreme form, whether a strong overdose of poison does more harm than the worms if they are allowed to have full sway? If the worms are very numerous they will not only defoliate the plants, but also destroy the blossoms, squares, and bolls, with the exception of the largest of these last. They eat the bark of the more tender twigs, and they very much injure the lint of the open bolls by the excrement and the particles of gnawed leaf which fall thereon, and not only stain it, but depreciate its value, since no ginning can entirely cleanse it. A strong overdose of poison kills the leaves and causes the blossoms and squares to drop, but does not so seriously affect the bolls. Fields stripped by the worms the latter part of August do not fully recover till about two months afterwards, while those which have been seriously injured by poison recover two weeks earlier. It will thus be seen that the injury caused by the worm is of a more serious nature than that caused by arsenical poisons, provided that the worms have been all killed by the poison. A small overdose of poison blisters or scorches the leaves, or, at worst, kills the

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more tender leaves; but it has, so far as our experience goes, no influence on the unopened blossoms,[46] the squares and bolls, and this slight injury is much less serious than that which would have been caused by the worms. With the improved machines and with some practice the best arsenical poisons can always be so applied that they will effectually destroy the worms within forty-eight hours and without injury to the plants. If the plant be injured to any considerable extent the fault will lie either in the mode of application or in the inferior quality of the poison.

Most of these arsenical poisons can be applied to the leaves either in water or dry, but some of the compounds are prepared so as to be used only in the former manner.

DRY APPLICATION.—When applied in powder the poison must be mixed with other ingredients, in order to render it sufficiently economical and to avoid injury to the plant. The ingredients should mix readily with the poison; they should be cheap and, in the application from above, as far as possible adhesive, in order to prevent their being washed away by the rains. Of the various ingredients that have been used with success common flour gives most satisfaction, though it is somewhat expensive. Flour not only mixes most readily and homogeneously with the poison, but possesses also great adhesive qualities, even without further admixtures. Other materials used with success as diluents are land plaster (gypsum) and cotton-seed meal, both being very cheap in some sections of the South, and to be recommended during dry weather, but having the disadvantage of being much less adhesive than flour. Both materials can, however, be advantageously used when mixed with the flour, the proportion being immaterial, provided the flour occupies the greater bulk. Finely-sifted wood ashes are not readily mixed or kept mixed with the much heavier arsenical poisons, and, having little adhesiveness, are not to be recommended alone, but are important when combined with flour.

By the admixture of about one-third of wood ashes to two-thirds of flour, the cost of the application is not only considerably lessened, but another important advantage is obtained. The action of rain and dew converts the flour on the plants into a kind of paste, which, while it adheres firmly to the leaves, is somewhat injurious by excluding the air and by increasing the caustic action of the poison. Both these difficulties are measurably overcome by the admixture of wood ashes, and the good results obtained in Texas in the application of various arsenical poisons are largely due to the prevalence of the use of such ashes. A good supply can be collected during the winter, at no expense and with but little trouble.

The substitution of common road dust for the diluents mentioned above has been taken into consideration, and we have carried on experiments as to its feasibility. The results show that very finely-sifted dust, which contains as little sand as possible, may, if nothing else is at

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hand, be used as a diluent, but that it is a poor substitute for flour. Its chief demerit is its greater weight, which renders the application both inconvenient and wasteful.

Before applying any poison in powder form it must be mixed with some of the diluents already mentioned. This mixing, generally done by farmers in a most primitive way by simply stirring the poison into a kettle or wooden box full of flour or other diluent, is a matter of no small importance, as the success or failure of the application largely depends on the way in which the mixing has been done.

Mr. George Little, of Columbus, Tex., has constructed a very simple and useful contrivance for mixing the ingredients. It consists of a barrel which has a longitudinal wooden axle projecting somewhat at each end. Five or six staves run through the barrel longitudinally, but do not project at either end, and on one side is an aperture large enough to admit the ingredients. When they are in, the aperture is closed and the barrel is placed over a large open box, or fixed in any way so that it can be revolved by means of a handle attached to the projecting axle. By this simple and cheap contrivance much labor is saved and a thorough mixing assured, while all possible danger which might be incurred by hand-mixing is avoided. Large spikes driven through the sides so as to project inwardly will add to the efficacy of the device.

In the matter of applying the powder, many planters prefer simply to scatter it by hand, after the manner of seed-sowing, as being more economical and rapid than any other method in use. It has, moreover, the advantage that, if the plants are high enough, the poison can be applied to the under side of the leaves. Planters who use this method assert, upon inquiry, that no evil consequences have ever followed their handling of the mixture in this way, but it strikes us as being altogether too unsafe to be recommended, and cannot compare on a large scale with the devices described in the ensuing chapters.

The principal expense in the dry application, as hitherto practised, consists not so much in the cost of the poison as in that of the diluents, and it occurred to us to try and reduce the amount of these diluents to a minimum or to dispense with them altogether by applying the required amount of poison unmixed. The experiments made in this direction have not been satisfactory for want of suitable machinery, the amount of poison used for each plant being always too large and not evenly distributed. They prove, however, that with our improved blowers much may be done in the direction of reducing the diluent.

In the application from above it has been found useful to add a certain amount of finely-powdered substances of still greater adhesive qualities than is possessed by any of the diluents mentioned, in order to prevent the poison from being washed away by the rain. Such substances are dextrine, gum arabic, slippery-elm bark, or rosin. In very rainy weather it is better to add a larger proportion of them than in dry

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weather. Two pounds of adhesive material to each 25 pounds of poison and diluents may be given as an average proportion.

The principles that should be followed in the dry application are, to mix the poison thoroughly with the diluents, and to apply the mixture as evenly and slightly as possible on the plants when the worms are still very young. The best time of the day to apply the poison is early in the morning when the plants are still wet with dew. Dry and windy weather is unfavorable to an even and economical application.

WET APPLICATION.—This is a much simpler process than the dry application. The required amount of poison is stirred up in a certain amount of water, the liquid being then evenly and economically distributed upon the leaves of the plants. The large series of machines invented for this purpose accomplish this in a more or less perfect way, the water being broken up into a very fine spray. Most of the arsenical poisons not being soluble in water must be kept suspended by stirring, but this difficulty is easily overcome either by the employment of an additional hand to keep the water stirred up or by adding to the various pumps with which the poison is distributed a simple self-acting lever inside of the barrel or other vessel containing it. This, together with the motion of the pump, is sufficient to prevent settlement. It pays to add two or three pounds of flour or starch to each barrel of the poison mixture, not only because of the greater adhesiveness which they give to the poison (a very desirable object, especially in wet weather), but because, by their color, they help to indicate the quantity that has been distributed, and, also, because they serve to keep the poisons suspended in the water. In using flour it will be found advisable to mix it first in a bucketful of water and allow it to remain until it sours, the object being to prevent it from forming lumps. Another ingredient that may be advantageously added is very finely sifted wood ashes in such quantity as not to interfere with the distribution of the poison. They tend to lessen the caustic action of the poison on the plant. The most important point in wet applications is to have a good supply of water handy and readily accessible near the field, and it should be as free as possible from impurities.

The best time for applying wet poisons is in the afternoon, or at least after the dew has disappeared. Dry weather is the most favorable, while in rainy weather the wet application, especially from above, should not be attempted.

The relative advantages and disadvantages of the two methods of applying arsenical poisons may be briefly summed up as follows: The wet application is by far the cheaper so long as we are obliged to use a large amount of costly diluents in the dry application. It is also the quickest method, as a liquid spray can be thrown over more rows of cotton than a dry powder. During dry weather the wet application is preferable, while in rainy weather the dry application may be found more advantageous or even necessary, not only because its effect is less

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impaired by the rains, but because dry poisons can, if necessary, be applied without the aid of heavy machines, which cannot be drawn through the fields in very wet weather. Dry arsenical poisons, especially when mixed with diluents, are much less liable to injure the plants than when applied in liquid suspension.

PARIS GREEN.

The nature and effects of this poison are now too well and generally known among planters to need consideration. Planters have too often found in its use a path leading from threatened ruin and bankruptcy to be much influenced by theoretical arguments against it. A study of its effects, based upon experience and experiment, whether upon the plant or upon the soil, shows that no harm results from its judicious use.* Our expectations in first suggesting its use as a Cotton Worm destroyer at the Saint Louis meeting of the National Agricultural Congress, in 1872, and more confidently recommending it before the same body at Indianapolis, in 1873, have been fully realized by the experience of the past seven years. Complaints of its inefficacy are readily traceable either to faulty application or to the use of an adulterated article. Its principal disadvantages are its great cost, often increased by the exorbitant profits demanded by merchants, and the consequent temptation to adulterate or imitate the genuine article.[47] Its advantage over the other arsenical poisons, besides its undoubted efficacy, is that it is least liable to scald the leaves and cause the young bolls to shed.

If used in liquid suspension the amount of the green to be distributed over one acre should not exceed one pound or be not less than half a pound. The former amount is that more generally used, but, taking into account the wastage and loss through rain or dew, the actual working quantity per acre is not much above one-half pound. The generally accepted practice has been to take 1 pound of the green to each 40 gallons of water, which amount of water was sufficient to go over one acre when applied from above in a moderately fine spray or rain.

The great advantage of the improved methods of application given in this report is that they extend a given amount of liquid poison over more than three times the area without loss of efficacy, and thereby reduce the cost to less than one-third of what it hitherto has been.

If the green were as cheap as the other arsenical poisons, this saving would be of little consequence; but, as the matter stands, it is of the greatest importance, as will be seen from the following computation: The price of Paris green in the South averages 40 cents per pound, being rarely lower, and in times of general demand reaching as high as 75 cents or $1 per pound. We arrive at the cost of the wet application per acre by adding to the cost of the poison and admixture that of the ma-

* A discussion of this subject will be found in a work by the writer entitled "Potato Pests," pp. 69-75.

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chine and the labor. Both of the last two items are extremely variable, and it is difficult to get at the average cost. One of the improved sprinklers will cost, on an average, say, $15, and will last for several seasons with but little expenditure for repairs. Two hands are necessary to operate the machine. One hundred acres of cotton can be poisoned in a day by these two men with one machine, 16 pounds of Paris green, and (not absolutely necessary) a small amount of flour and ashes.

This dry method of applying Paris green has proved satisfactory under the conditions already referred to whenever a genuine article has been obtained and properly applied. Reported cases of failure must be attributed to adulterated poison, or to the use during very wet weather of ingredients of inferior quality. The proportion of the green to the ingredients actually in use in the South varies from 1 pound of the green to 20 pounds of ingredients, to 1 pound of green to about 35 pounds of ingredients, the stronger mixture being generally adopted in Texas, the weaker in the more eastern portion of the cotton belt. This great difference is partially explained by the fact that the mixture is as a rule more economically applied in Texas than further east. The original idea was to distribute 1 pound of the green over one acre of cotton of average size, and by a very slow and careful manipulation of the sieves it is indeed barely possible to accomplish this satisfactorily if 20 pounds of ingredients are added. Practically, however, the amount of the mixture used per acre always exceeds 30 pounds, and often reaches 50 pounds or even more. This great waste is the necessary consequence of the imperfect implements that have been employed so far, and partially also of the carelessness of the hands. The small tin sieves so extensively used in the cane-brake region of Alabama are especially wasteful in the distribution of the mixture, and one barrel (almost 200 pounds) is, on some plantations, not expected to go over much more than three acres. That 1 pound of the green to 30 pounds of diluents applied at the rate of not more than 20 pounds to the acre is efficient has been proved by actual experience over and over again, and all stronger admixtures of the green should, therefore, be abandoned. But in every application of this mixture during dry weather another point of still greater importance can be learned: Wherever the mixture is applied very slightly, so as to be a mere dusting of the leaves, it is fully as efficient as where it thickly covers the plant. One of the chief aims we have had in mind has been to ascertain by experiment the minimum quantity of the poison that could advantageously be used, and Mr. Schwarz was intrusted with experiments in this direction. He reports as follows:

"*Minimum quantity of Paris green.*—That the method of applying dry poisons by means of common bread-sieves, and still more by means of small tin sieves, is a very wasteful one, needs no further remark, and a

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large series of trials with poisons in powder form convinced me that this waste cannot be materially lessened by a careful handling of the sieve, or by employing several more layers of muslin in addition to the one or two now generally used. Application by means of the bellows is too irregular, while application with the hand is, with some practice, considerably less wasteful.

"The most economical distribution of the mixture I could devise, for experiments on a small scale, was by means of a stiff brush. A common shoe-brush is dipped in a flat vessel containing the mixture.[48] The greatest portion of the adhering poison is then shaken off by knocking with a stick on the handle of the brush. The still adhering poison is then thrown on the plants by drawing a stick across the brush. The poison can thus be applied from any direction, and the amount be regulated at will. Three average-sized plants were accordingly dusted on September 2; the first very slightly from above, the two others from below. In applying from below, the poison finally covers both the underside as well as the upper side of the leaves. I am quite unable, however, to calculate the amount of poison mixture I used, but it is certain that each plant did not receive the tenth part of the amount it would have received in the applications with the sieve. The plants were dusted early in the morning, the poison adhering very well also to the underside of the leaves. There were numerous worms on all plants at this time, while others were continually hatching. A moderate rain shower about six hours after application washed off most of the poison applied from above, while it had but little influence on that applied from below. However, wherever there were holes in the leaves, the poison on the underside was converted into paste, and, in a few places, washed away.

"The application on the first plant proved to be of very little use, though I found three dead worms under the plant next morning. The two other plants were, however, fully protected for about five days, and almost entirely cleared from the worms, when the migratory worms overran them. Against the superior number of these worms the poison was of no avail, though a vast number of them were killed before the plants were stripped. I have not the slightest doubt, however, that in ordinary times such slight application of dry Paris green from below is fully sufficient to protect the plants."

That such application from below is not only practically possible, but can be effected much more rapidly than the sieving method, will be demonstrated further on in discussing the machines invented for this purpose. The adoption of the new machines will considerably reduce the cost of the dry application of Paris green without in the least lessening its efficacy. Its cost per acre of cotton, when applied with the sieve, ranges from 75 cents to $2, according to the first cost of material and different modes of application, or, again, to the size of the plants at the time of the application.

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Five patents have been issued for different combinations with Paris green. In 1868 Mr. J. P. Wilson, of Illinois, took out a patent (No. 82468) for one part of Paris green and two of mineral paint to be used to kill potato-bugs. In 1871 Mr. Lemuel Pagin, of Niles, Mich., claimed a mixture (patent No. 112732: Paris green, 2 pounds; rosin, 2½ pounds; gum arabic or slippery-elm, ¼ pound; wheat-flour, 5 pounds; middlings, 1 bushel) for the same purpose. In 1873 Mr. G. F. Whisenant, of Chapel Hill, Texas, obtained a patent (No. 134959: Paris green, ¼ pound; arsenic, 1 pound; lime, 26 pounds, and flour 5 pounds) for destroying caterpillars on cotton. In the same year Mr. William B. Royall, of Brenham, Tex., obtained patent for the same purpose (No. 140079, June 17, 1873), the ingredients being Paris green, 1 pound; cobalt, 2 ounces; flour, 17 pounds; powdered gum tragacanth, 3 ounces; powdered licorice root, 6 ounces; and subsequently still another (No. 151439, May 26, 1874: Paris green, 1 pound; flour, 4 pounds; cotton-seed meal, 16 pounds) for the substitution in part of cotton-seed meal for ordinary flour.

Regarding these patent mixtures it must be borne in mind that the value of Paris green with some diluent as an insecticide had been widely made public before any of them were issued, and we can but repeat our previously expressed opinion* that "it is to be regretted that patents can be obtained at all for remedies of this nature after they have become generally known and rightfully belong to the public. When the discoverer of such a remedy does not see fit to patent it, no one subsequently has a moral right to, whatever speculative right he may possess. Fortunately, in this case the patentees cannot interfere with the public rights, and it is be to hoped that no planter, either of potatoes or cotton, will be induced by flaming circulars and threats to pay even one cent per thousand acres, much less the demanded $20 per 100 acres, for the privilege of using these patented mixtures. The very fact that so many patents have been granted for the same purpose, all of them having Paris green as a base, shows clearly that the patent covers only the particular combination. By ringing the changes on the different proportions of the several ingredients, a thousand of these patent remedies may be obtained; and any one who diverges but a fraction from the particular patented combination ceases to infringe upon it. It will therefore be utterly impossible for the patentees to enforce the penalty for infringement without proof that precisely the same ingredients and combination as patented were used; and to get such proof will, I take it, be no easy matter; for were it, we should hear of hundreds of thousands, of prosecutions where now we hear not of a single one."

Experience has justified this advice; for, while immense sums have been paid by planters to some parties for the right to use Paris green mixtures, the patentees have been unable to get protection from the courts whenever they have sued for infringement in the independent

*Sixth Rep. Ins. Mo., 1873, p. 21.

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use of them by planters. The letter of the law too often negatives the spirit of the law, and it seems that the Patent Office has been forced to issue the patents above alluded to on the ground and decision that any change in the compounds of a mixture makes of it, in law, a new substance.

ARSENIC.

While commercial arsenic, salts of arsenic, and their various compounds are much cheaper than Paris green, yet this advantage is more than counterbalanced by the injurious property they possess, in a more or less marked degree, of scalding the leaves and causing the squares and young bolls to shed. Moreover, on account of their white color, there is more danger of injury to man and animals in their use than in that of colored preparations, which are less likely to be mistaken for harmless substances. Great care and precaution are, therefore, necessary in applying these arsenic poisons. When applied in just the right proportions to kill the worms without injuring the cotton they are valuable substitutes for the more expensive Paris green, but unfortunately these proportions vary with each particular combination, the condition of the plants, temperature, and weather, and time of application, so that they can be satisfactorily ascertained only by absolute experiment.

It is for this reason that the Paris green mixtures have held their own against the cheaper compounds, and most planters, even where these last are used, find it desirable to still mix a certain proportion of the green with them.

The cheapness of the arsenic, combined with the fact that under very favorable circumstances it is not uncommonly applied with success, will give to it a conspicuous place among the remedies for the Cotton Worm, so long as mineral poisons are not superseded by others. The high price asked for some of the patented compounds is entirely unwarranted, as their value in every case depends on the arsenic.

Commercial arsenic, costing from 7 to 10 cents per pound, is applied in powder form at the ratio of ½ pound to from 18 to 25 of any of the ingredients used with Paris green. Used in water, these arsenic compounds give less satisfaction because of the dangers to the plant already alluded to, which are then increased. Counting 40 gallons of liquid for one acre of cotton, the arsenic used should not exceed 1 pound to 200 gallons of water; and this mixture must be very evenly distributed, as even a slight overdose will scorch the leaves. It is an interesting fact that already in 1871 a patent was obtained for the use of arsenic against the Cotton Worm by Mr. Thomas W. Mitchell, of Richmond, Tex. (No. 110774, January 3, 1871; reissue No. 5935, June 30, 1874: 92 grains of opaque arsenic, or 293 grains of transparent arsenic to one pint of water).

Arseniate of soda.—This has the advantage of being perfectly sol-

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uble in water, but has the same disadvantages as commercial arsenic. For a number of years an arsenical compound has been advertised under the name of "Potato-pest poison," by the Lodi Chemical Works of Lodi, N. J. It is put up in pound packages, which are sold at $1 each, with directions to dissolve 4 ounces in 2 quarts of hot water, then pour into a barrel containing 30 gallons of cold water, and use on the plants in as fine a spray as possible.

The common arsenic water, which every druggist knows how to make, will answer well. To make it from the *white arsenic* (arsenious acid) and common baking (carbonate of) soda is *cheaper* than to buy the arseniate, although the arseniate method of preparation involves less time and labor. One-fifth of a pound of sal soda to a pound of arsenic should be boiled in a gallon of water until dissolved. The solution is permanent, *no stirring* or shaking being necessary to keep the poison mixed. One quart of the solution to forty gallons of water is used on each acre.

Fowler's solution.—This compound is said to consist of arsenious oxide, dissolved in a solution of sodium or potassium carbonate in water. It has been used quite extensively in some parts of the canebrake region of Alabama, but does not appear to be patented.

A more complicated compound, "JOHNSON'S DEAD SHOT," has been patented by Judge J. W. Johnson, of Columbus, Tex. (No. 151,666, June 2, 1874), consisting of 8 ounces arsenious acid, 1 ounce cyanide of potassium, 8 ounces dextrine, dissolved in 40 gallons of water. One of the claims for this compound was that the vapor of the cyanide of potassium even killed the moths which came in the vicinity of the plants that had been sprinkled with the "Dead Shot." Experience has shown that the claim was unwarranted, and in fact, in the packages offered to the public, Judge Johnson did not adhere to the specification, being finally afraid to use the cyanide of potassium, and making a mixture composed of 3 pounds of commercial arsenic, 1 pound of starch, 1 pound of salts of tartar, ground up together. This was made up in powder packages, to be used at the rate of 5 pounds to 500 gallons of water, and sprayed by means of his patent sprinkler presently to be described. This was found to have the same drawback, common to arsenical mixtures, of injuring the plant, and the later packages, advertised under the name of "Johnson's Improved Dead Shot," put up in 4-pound tin boxes, and to be used at the rate of 4 pounds to 500 gallons of water, consist (according to the inventor's own statement to us) of 2 pounds of commercial arsenic with a due proportion of rosin, caustic soda, and sulphate of copper, all boiled together. This is sold at $1.25 per box. It has, however, proved too often unsatisfactory and inefficient, and Mr. Johnson has been obliged to add or recommend the addition of one pound of Paris green to the mixture.

A patent (No. 151078, May 19, 1874) was obtained by Messrs. J. D. Braham and A. Robira, of Galveston, Tex., for their "TEXAS COTTON

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WORM DESTROYER," which is essentially the same as the Lodi preparation, and put up at the New Jersey works for the Galveston firm. Fifty grains of arseniate of soda and 200 grains of dextrine are to be dissolved in one gallon of cold water. The mixture formerly sold at the exorbitant price of $1 per pound, and is now offered for 50 cents per pound. It is put up in packages of 60 and 100 pounds, and thus sold at a discount of 10 per cent. It is to be used at the rate of 4 ounces of the mixture to about 40 gallons of water, making the cost of one application per acre about 12½ cents. It has been extensively used.

Another "pest poison," also essentially the same as the Lodi preparation, but faintly colored with rose aniline, is put up by the Kearney Chemical Works of New York, in ½-pound packages, sold at 50 cents, and to be dissolved in 60 gallons of water.

LONDON PURPLE.

This powder is obtained in the following manner in the manufacture of aniline dyes: Crude coal-oil is distilled to produce benzole. This is mixed with nitric acid, and forms nitro-benzole. Iron filings are then used to produce nascent hydrogen with the excess of nitric acid in the benzole. When distilled, aniline results: to this are added arsenic acid, to give an atom of oxygen which produces rose aniline, and quicklime to absorb the arsenic. The residuum which is obtained by filtration or settling is what has been denominated "London purple," the sediment being dried, powdered, and finely bolted. The powder is, therefore, composed of lime and arsenious acid, with about 25 per cent. of carbonaceous matter which surrounds every atom. Experiments which we made with it in 1878 impressed us favorably with this powder as an insecticide, and its use on the Colorado potato-beetle by Professors Budd and Bessey, of the Iowa Agricultural College, proved highly satisfactory. We were, therefore, quite anxious to test its effect on the Cotton Worm in the field on a large scale, and in the winter of 1878–'79 induced the manufacturers to send a large quantity for this purpose to the Department of Agriculture. The analysis made of it by Professor Collier, the chemist of the Department, showed it to contain:

	Per cent.
Rose aniline	12.46
Arsenic acid	43.65
Lime	21.82
Insoluble residue	14.57
Iron oxide	1.16
Water	2.27
Loss	4.07
	100.00

Through the liberality of the manufacturers, Messrs. Hemingway & Co., a number of barrels of this powder were placed at our disposal

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during the season of 1879 and distributed to various observers and agents in Georgia, Alabama, and Texas. Early in the spring of the following year Mr. A. R. Whitney, of Franklin Grove, Ill., found it to be a perfect antidote to the canker-worms which had not been prevented from ascending his apple trees.

In the following year (1880) large quantities of the purple were used by many planters in various parts of the cotton belt, while, at the same time, in the Northern States the experiments were vigorously continued. It would lead us too far to report and discuss here all the experiments which have been made on other insects than the Cotton Worm, and it suffices to state briefly that the purple has proved to be a perfect substitute for Paris green. As to its value as a remedy for the Cotton Worm, the matter stands as follows: In Texas, where the purple has been most extensively used, according, as we may add here, to the directions given by us, the unanimous verdict of the planters is in its favor, not a single case of failure having been reported. We have on file very many reports and letters received from that State, and statements that have appeared in the daily papers which express this favorable opinion. In the other States the opinion is not uniform on the subject, and there has been, especially in Alabama, considerable adverse experience with it. Mr. James Roane, agent of the Commission, wrote as follows on the subject:

"I have been introduced to quite a number of planters, and upon conversing with them find that they are divided as to the efficacy of London purple. Some repudiate it altogether, while others are loud in its praises. One thing is certain, that there has been a very large demand for it. Mr. Wilkins tells me that in the space of one day he sold no less than 2,000 pounds, saying at the same time that he could have readily disposed of 20,000 pounds if he had had it. Major Hardie, who, as you know, is a gentleman of the highest cultivation and attainments, tells me that he has little faith in London purple, having used it on his plantation under his direct supervision, without obtaining the satisfactory results of Paris green. He mixes 1 pound of the purple with 40 of flour, and sifts it over the plant. The main objection he urges against it is its failure to kill the worm anything like as quickly as Paris green. He acknowledges, however, that next to Paris green it is the best, because the only remedy to be obtained.

"Immediately after Major Hardie gave his opinion on the purple, an old planter, who just stepped in, said that he had used London purple very extensively on his cotton-fields with the most flattering results. He used the poison suspended in water."

In the majority of cases the failure was plainly due to an overdose of the poison applied, many planters having used it in the same proportion as Paris green, simply because they chanced to have read Mr. Trelease's report (see Report on Cotton Insects, 1879, Department of Agriculture), who, strangely enough, always experimented with strong

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overdoses of London purple. In other cases the failure was plainly to be attributed to the imperfect implements used for the distribution of the dry and wet poisons. In still other cases the cause of the failure could not be made out. The conclusions we arrived at during the season of 1879, after a long series of trials made by ourself and Mr. Schwarz, and assisted by the most experienced planters in the vicinity of Columbus, Tex., and which were published in the first edition of this work, have been proved correct by the experience of subsequent years, and wherever pure and genuine London purple has been applied according to the directions, it has always given satisfactory results.

It should be remembered that the introduction of a new remedy, especially if it is not without drawbacks, is always a difficult task, and experience must be bought at the cost of disappointment and failure. We need only recall to the reader the history of the introduction of the Paris green, and how long it took before its efficacy was firmly established, and before the farmers and planters had gained full confidence that it was a perfect remedy for some of our worst insect enemies. London purple has, in common with all arsenical poisons, the disadvantage of danger, but it is one of the cheapest remedies of this class, being a mere refuse which, from its poisonous nature, was a drug to the manufacturers, and had to be gotten rid of by being dumped long distances out at sea. This substance can be put upon the market at the bare cost of transportation. It can be sold in New York at the low rate of 6 cents per pound, and there is no reason why it should not be obtained at any of the large shipping points in the South at figures ranging between 7 and 10 cents a pound. This means virtually that the cost of destroying the worms by this powder is reduced to such a minimum as to depend mainly on the labor and the other ingredients or diluents employed; in other words, that, while the planters, as heretofore, were obliged to pay as much as $1 for the first cost of the active poison needed for one acre, and never less than 15 cents, they may now obtain it for from 3 to 5 cents.

An advantage of minor importance is its red hue, as it colors the ingredients so as to prevent their being mistaken for harmless material. The finely pulverized condition of the purple seems to be of less advantage than we were formerly inclined to believe, as it increases the caustic power of the poison upon the plants. Finally, its cheap price removes the temptation of adulterating the poison, as every adulteration would prove more expensive than the genuine article.

Dry application.—Experiments on a large scale have been made with the dry application at the rate of 2 pounds to 18 pounds of diluents, also at the rates of 1, ½, ¼, and ⅛ pound to 18 of the diluents. The last proved only partially effectual, and in no case were the plants injured or the leaves even burned. In all but the last case the worms were killed, but as the mixture, at the rate of ¼ pound, was applied with greater care and regularity than is generally had on a large scale, and

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also in very dry weather, the proportion of ½ pound to 18 of the diluents is most to be recommended. This refers to very economical application by means of a careful handling of the sieves. As the sifting is generally done less economically, the following proportion is to be recommended: One pound of the purple to about 45 pounds of diluents, the latter most advantageously consisting of 15 pounds of wood ashes and 30 pounds of flour, including the usual amount of adhesive materials. This would give about 4 pounds of the purple to 1 barrel of flour. As to the cost per acre of cotton, the remarks made under the head of Paris green also hold true here, the low price of the purple rendering its application of course so much cheaper.

The experiments made by the agents of the Commission in applying the purple without diluents have completely failed for want of machines wherewith to apply evenly the very small quantity of the poison required for each plant, the results invariably being that the leaves were considerably scorched. The invention of machines bringing about the even distribution of very small quantities of poison will naturally open a wide field for further experimentation. That even a very slight dusting with the purple mixture mentioned above is fully efficient has been proved by the experiments made in Texas in 1879; but such economic application is impossible on a large scale, so long as we cannot dispense with the sifting methods.

Wet application.—Like Paris green, it is not soluble,* but is much easier kept suspended in water than the former. If applied in this way some care has to be taken in stirring it in the water, as it has a tendency to form lumps, owing to its finely-powdered condition. Experiments on a large scale with this material diluted in water gave the following results: When used in the same proportion as Paris green, namely, 1 pound of the poison to about 40 gallons of water, one experimenter reports that the leaves were slightly crisped, while four others report perfect success, and no injury whatever to the plant. Experiments by ourself and Mr. Schwarz in the year 1879 showed that when applied in the proportion mentioned and thoroughly stirred up in the water the leaves were partly crisped, though by no means so much as by arsenic, even when applied in weaker solution. When used in smaller proportion, or at the rate of ¾ or ½ pound to 40 gallons of water, it did not burn the leaves, and still proved effectual in destroying the worms. Repeated experiments on a smaller scale confirmed these results obtained on large fields, and also showed that the proportion may be still farther reduced, and when applied with great care and in very dry weather ¼ pound to 40 gallons will kill. Still farther reduction in the proportion of the powder used gave negative results. I would therefore recommend the use of ½ pound of this powder to from 50 to 55 gallons of water as the proportion most likely to give general satisfaction by effectually destroying the worms without injuring the plants.

* The manufacturers can render about 13 per cent. of it soluble if desired.

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All that has been said under the head of Paris green as to the desirability of adding a small quantity of flour or other substance to give adhesiveness to the liquid will hold equally true of London purple. This method is very cheap; labor and machine constituting by far the greatest part of the expense, while the cost of the poison per acre does not exceed 3 cents.

OTHER MINERAL SUBSTANCES.

SALT AND SALTPETRE.

We have heard common salt frequently recommended as a remedy for injurious insects, and it unquestionably possesses insecticide properties, especially when dissolved in water, affecting and killing the insect upon contact. Unfortunately, however, its effects on the plants are much more marked, and we have thus the same obstacles to its application as with kerosene and other oils. Moreover, salt is decidedly inferior to kerosene as an insecticide, but scarcely less injurious to the plant; hence in the case of salt it is much more difficult to find the "right proportion" in which it could effectually be applied; in other words, that proportion of salt which is not injurious to the plant will be much too weak to seriously affect the worms.

Nevertheless, in view of the constantly recurring recommendations of salt as remedy for the Cotton Worms in the papers, we had some experiments made in the field by Professor Stelle and Mr. Schwarz. The former gives the following report in his diary:

September 27, 1880.—Sprinkled two rows of cotton across a square acre with a solution made of saltpetre in proportion of 1 ounce to the gallon of water; also two rows with a solution of common salt, 3 ounces to the gallon of water.

September 28.—Can see an effect favorable on all the rows of cotton sprayed yesterday, though the worms have not entirely disappeared from any.

September 29.—Looking over my work on Monday, I find considerably less worms on the saltpetre rows than where nothing has been used, and very few indeed where the common salt was applied. The salt has slightly curled some of the leaves. Sprinkled two rows carefully with common salt in proportion of 2 ounces to the gallon of water.

September 30.—The rows sprinkled with salt yesterday have shown no satisfactory result.

This report would seem to give a satisfactory result as to the application of salpeter, but no further experiments have been made so far.

Much less favorable is the following report by Mr. Schwarz on an experiment made with common salt:

August 26.—I applied common salt in the proportion recommended to me, viz., at the rate of 1 gallon of salt to 40 gallons of water. The salt was thoroughly dissolved in the water and the liquid applied by means of the fountain pump, wetting the leaves on some plants pretty thoroughly. Upon examination, 16 hours afterwards, a small number of dead worms (not 10 per cent. of the whole number), mostly young ones, were found, the leaves being somewhat shriveled up even where not exposed to the sun; but wherever the solution was applied thickly the leaves had assumed a peculiar pale green color and were quite stiff. The worms did not feed upon such leaves, which, on the second day, proved to be killed.

August 28.—Applied the solution at the rate of 1 gallon of salt to 80 gallons of water. No effect upon worms observed the next day or afterwards.

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SULPHUR.

A machine for the application of the vapor of this mineral is described in Chapter XIII; but, so far as we can see, the machine has not been used to any extent. Nor is it probable that sulphur vapor will destroy the worms, when applied in the open air.

RED LEAD.

The following account of experiments with this substance is from Mr. Schwarz's report:

At the suggestion of Professor Barnard I made a few experiments with red lead. September 4 I dusted five worms slightly with the powder and placed them in a glass jar together with a few fresh leaves. No effect visible after twenty-four or forty-eight hours. Placed a few worms in a glass jar and fed them with leaves thickly dusted with red lead. After eight hours no effect visible, but the worms did not seem to have eaten of the leaves. After twenty-four hours three of the worms were dead, two others showed the color peculiar to those poisoned by Paris green or London purple and died in the course of the day.

September 19.—Red lead diluted with five parts of flour and the mixture thrown on some plants which were fairly alive with young worms. Twenty-four hours afterwards some poisoned worms were found; thirty-six hours after application some more dead worms, but in the mean time most of the mixture had been washed away by a heavy rain, and the remaining worms were sufficient to defoliate the plants. I fully believe, however, that this mixture would have been efficient to protect the plant if the rain had not interfered.

September 22.—Applied a mixture of one part red lead to ten of flour. Within 48 hours I noticed a few dead young worms, presumably killed by the poison, but most of the worms were not affected, or, if so, not seriously affected. I had no further opportunity to experiment with this substance, but do not believe it can be advantageously used as a substitute for Paris green or London purple, as it evidently does not act so powerfully as either of the two. Further experiments are, however, necessary to obtain a definite opinion regarding its value as an insecticide. Its price (so far as I understood) is cheaper than Paris green, but more expensive than London purple. Its value as an insecticide will, of course, depend also upon its influence on the plant, a circumstance to which I omitted to pay attention, though there was certainly no marked injurious influence in my experiments.

ROAD DUST AND ALLIED SUBSTANCES.

The protection from the attacks of the worm and the prevention of the ovipositing of the moth accomplished by thickly dusting the leaves on both sides has already been mentioned on page 126. It still remains here to speak of the property of road dust to drive off or kill the worms. If a powerful jet of water is directed on the soil at the base of the plant so as to splash the softened mud on the lower leaves, the worms on them will be covered with the soil and many of the young ones are unable to remove it. They fall to the ground and exhaust themselves in frantic and fruitless efforts to clean themselves. The same result can be accomplished by throwing dry dust on the plant during or shortly after rainy weather, or after the plants have been thoroughly wetted with a sprinkler.

Not every kind of dust is suitable for this purpose, and for utilizing

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it as a substitute for flour in the application of arsenical poisons and pyrethrum powder. On this subject Mr. Schwarz reports as follows:

At first I selected dust from the nearest road at hand and sifted it through a very fine sieve covered with a quadruple layer of fine muslin. I found, however, that this dust was largely composed of particles of sand without any adhesive power whatever, and which, moreover, rendered the dust very heavy and quite unsuitable for any experiment. This sand is very fine, and I failed to eliminate it by using additional layers of muslin. I did not succeed better with dust prepared from the dry clay so common along the river bank near Selma. Finally I obtained a suitable very fine dust by sifting the rich black earth, which of course I had previously well dried. This dust is comparatively light, and of considerable adhesive power even in dry weather.

While we attach but limited value to dust either for preventing the moths from ovipositing, driving off the worms, or killing them in the manner just mentioned, still it might prove valuable as a diluent for arsenical poisons where flour and other diluents cannot be obtained, and more attention ought to be paid to this cheap and easily obtainable substance as a remedy for various insect pests other than the Cotton Worm. The insecticide property of dust mentioned in this connection is not peculiar to road dust alone, but is possessed by every substance which adheres to the worms in a sticky, paste-like covering. Thus by the application of flour stirred up in water many small worms may be killed, and the only results obtained by our agents in the application of diluted dough and yeast are attributable to their action in the manner here alluded to.

OILS AND ALLIED SUBSTANCES.

KEROSENE.

It is a well-known fact that this is a most powerful insecticide, and experiment has shown that a fine spray of kerosene applied to the leaves will kill all worms thereon in a remarkably short time. This deadly effect is produced by contact, a very small quantity of the oil applied to the worm causing death. We have thus a very cheap and sure remedy, which, moreover, cannot be called poisonous to higher animals, but unfortunately the oil has the same pernicious effect on the plant as on insect life, and the problem is to apply it in such fine spray, or so much diluted as not to injure the plant and at the same time touch every worm. The finest spray, produced by a parlor atomizer, of the undiluted oil is sufficient to kill the leaves, the cotton plant proving to be exceedingly sensitive to the effect of the oil, much more so, in fact, than many other plants. The use of the undiluted oil being, therefore, impracticable, there remains only to try to apply it in dilution. The only available diluent hitherto known being water, a new difficulty arises, viz., to mix the oil with the water so as to produce a homogeneous or nearly homogeneous mixture of the two. To a limited extent, and only on a small scale, this can be accomplished by very violently agitating the mixture. More useful, but also practicable only on a small scale, is the following method, recommended by Mr. William Saunders, of the Department of

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Agriculture: "The requisite amount of kerosene and water is placed in a barrel or pail, and with the syringe a syringeful several times squirted into the barrel, when the mixture must be quickly applied before the oil and water separate." When converted into soap by means of lye and boiling, kerosene, like any other oil, can easily be diluted with water to any extent, but loses in this form much of its deadly quality; hence its application in soap form has but little effect on the Cotton Worm, though it is more useful for many other insects more readily affected by saponaceous compounds.

When mixed with a sufficiently large quantity of wood ashes, kerosene can be applied to the leaves without damaging them, but the mixture cannot be sprinkled in particles small enough to have much effect on the worms. A patent was obtained by Mr. George W. Powell, of Halifax County, Virginia, in April, 1876, for the simple mixture of one-half pint of kerosene to one quart of fine, dry, well-sifted wood ashes. The patentee claims that by sprinkling or scattering this preparation lightly over the plants it will drive off or destroy insects of every kind without injury to the leaves.

An attempt has been made to apply the oil in form of vapor by means of steam. There is no question but that the worms are killed by this application, and, perhaps, without injury to the plant; but the machine necessary for the production of the vapor, which will be described further on, is so ponderous and awkward as to be of no practical value.

The above-mentioned methods of applying kerosene are of little or no value in our warfare against the Cotton-Worm but an important step toward a practical solution of this difficult question was made in the summer of 1880. Professor Barnard, while in the field at Selma, Ala., suggested the use of milk as a medium to facilitate the mixing of kerosene and water. First it was found that the oil mixes much more readily with the milk than with water. If a small quantity of the oil is stirred up in a much larger quantity of milk, the oil particles will remain much longer suspended in the milk than in water, thus permitting a practical application of the mixture. It was further found that even a large proportion of the kerosene could be mixed with milk by violently shaking up the closed vessel containing the mixture. Thus one part of kerosene to two parts of milk would unite after several minutes' shaking to form a kind of emulsion, in which the two ingredients did not separate until after many hours, and which then could always be restored, by shaking, to its apparently homogeneous condition. Though, in the light of subsequent discoveries, this emulsion proved to be a very imperfect one, and, in fact, no emulsion at all, but only a more or less finely divided mixture of the oil and milk, still it was found most useful for experimentation on a small scale and vastly superior to any of the old methods of applying kerosene. There was no difficulty experienced in experiments on a small scale in diluting this emulsion of one part of kerosene with three parts of milk with any desired quantity of water. A portion of the oil sep-

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arated soon and rose to the surface of the water, but the larger portion of the oil remained suspended in the water for a considerable length of time. Whatever were the shortcomings of this discovery at the time, we called attention to it in a communication to the *Scientific American*,* and it is difficult to understand why its importance was not fully appreciated by all interested in economic entomology. As it was it proved to be the stepping-stone to the successful solution of the problem of mixing kerosene with water without changing the nature of the former. This mode of obtaining a perfect and stable emulsion was discovered by Mr. Hubbard while experimenting with kerosene for scale-insects affecting the orange tree. We quote his description of it.†

"The process of forming a perfectly stable emulsion of kerosene and milk is comparable to that of ordinary butter making, and is as follows; The oil and milk in any desired proportions are poured together and very violently dashed or churned for a period of time, varying with the temperature, from fifteen to forty-five minutes. The churning, however, requires to be much more violent than can be effected with an ordinary butter-churn.

"The Aquapult force pump * * * may be satisfactorily used for this purpose where moderate quantities only are required. The pump should be inserted in a pail or tub containing the liquids, which are then forced into union by continuous pumping back into the same receptacle through the flexible hose and spray-nozzle. After passing once or twice through this pump the liquids unite and form a creamy emulsion, in which finely divided particles of oil can plainly be detected. This is as far as the process can be carried by stirring or by dashing in an ordinary churn; the product at this point will not bear diluting with water and separates or rises at once to the surface. On continued churning through the pump the liquid finally curdles and suddenly thickens to form a white and glistening butter, perfectly homogeneous in texture, and stable.

"The whole amount of both ingredients solidify together, and there is no whey or other residue; if, however, the quantity of the mixture is greater than can be kept in constant agitation, a portion of the oil is apt to separate at the moment of emulsification and will require the addition of a few ounces of milk and further churning for its reduction.

"This kerosene butter mixes readily in water, care being taken to thin it first with a small quantity of the liquid. The time required to "bring the butter" varies with the temperature. At 60° F. it is half to three-quarters of an hour; at 75°, fifteen minutes, and the process may be still further facilitated by heating the milk up to, but not past, the boiling point. Either fresh or sour milk may be used, and the latter is even preferable.

"The presence of kerosene does not prevent or hinder the fermentation of the milk; on standing a day or two the milk curdles, and although there is no separation of the oil the emulsion thickens and hardens and requires to be stirred, but not churned, until it regains its former smoothness.

"If sour milk is used no further fermentation takes place, and if not exposed to the air the kerosene butter can be kept unchanged for any length of time. Exposure to the air not only permits the evaporation of the oil but also of the water necessary to hold the oil in emulsion; the kerosene slowly separates as the emulsion dries up and hardens.

"Kerosene emulsions may be made of almost any strength; the quantity of milk required to hold the oil does not exceed one-tenth. But emulsions containing over 80 per cent. of the oils have too light a specific gravity and are not too readily held in suspension in water. On the other hand, the process of emulsification, kerosene loses

* *Scientific American*, October 16, 1880.

† Annual Report Department of Agriculture, 1881-'82, pp. 112, 113.

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a portion of its value as an insecticide, and emulsions containing less than 30 per cent. of the oil, although they do not at all, or only very slowly, rise to the surface when diluted with considerable quantities of water, are nevertheless too much weakened for effective use against Scale insects.

"The killing power of a diluted emulsion depends less upon the amount of emulsion used in the solution than upon the percentage of oil contained in the emulsion. To increase the efficiency of an application we should rather add to the percentage of oil in the emulsion than increase the gross amount of emulsion used in a single application, the amount of the diluent remaining in each case the same."

The following emulsions were used in the orange insect investigation by Mr. Hubbard, and were published in the Annual Report of the Department of Agriculture for 1881 and 1882, p. 115:

Kerosene, 1 pint; sour cow's milk, 2 fluid ounces, dashed with a ladle; 2 drachms of powdered chalk was first added to the milk, and 2 ounces water during the stirring.

An imperfect emulsion not readily suspended in water.

Kerosene, 1 quart; solution of condensed milk, 3 parts; water, 5 parts, 12 fluid ounces.

Emulsion made by spraying through the Aquapult pump and back into the pail. Stable, and readily suspended in water.

Kerosene, 1 quart; condensed milk, 12 fluid ounces, diluted with water, 36 ounces; emulsified with the Aquapult.

Kerosene, 25.6 fluid ounces; condensed milk, 4.8 fluid ounces; water, 14.4 ounces; emulsified with pump.

Kerosene, 2 quarts; condensed milk, 12 fluid ounces (1 can), water, 20 ounces; with pump.

Kerosene, 2 quarts, 4 fluid ounces; condensed milk, 12 fluid ounces; water, 24 ounces; with pump.

The following kerosene and soap emulsion has more recently been recommended by Mr. Hubbard:

Kerosene, 2 gallons. Common soap, ½ pound; water, 1 gallon.

Heat the mixture of soap and water, and add it, boiling hot, to the kerosene. Churn the mixture by means of a force-pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream, which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute, before using, 1 part of the emulsion with 9 parts of cold water. The above formula gives 3 gallons of emulsion, and makes, when diluted, 30 gallons of wash.

With this important discovery a wide field for further experimentation with kerosene has been opened, while at the same time the perfected atomizing machines permit the kerosene water to be applied, even on a large scale and from below, in such fine spray as to greatly lessen the danger resulting from the influence of the kerosene on the plants. These improvements, in material as well as in appliances, being of recent date, we have had but little opportunity to try them in the field for the Cotton Worm. The experiments in 1880 of Mr. Schwarz, and upon which he gives the following report, were made with the imperfect emulsion mentioned above:

In my experiments with kerosene I uniformly used an emulsion of 1 part of kerosene to 3 parts of milk. In view of the opinion expressed by Professor Comstock that such emulsion cannot be diluted with water, I would state that neither Professor Barnard nor myself experienced the slightest difficulty in this respect. This discrepancy is in all probability due to the circumstance that our experiments were carried on on a small scale, where the difficulties in mixing the two ingredients are

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hardly felt. Moreover, Professor Comstock's "emulsion" may have been less perfect than that used by ourselves. The kerosene water was applied in the following experiments by means of a hand-atomizer, because from former experience I felt convinced that the oil can successfully be applied only in the form of the finest spray. Refined kerosene was used, instead of crude coal oil, because the former was more readily procured at Selma than the latter. From my experience with the crude coal oil in 1879, I am inclined to think that there is not much difference between the two, either in regard to insecticide property or to their injurious effect on the plant. The chief difficulty to overcome in the application of kerosene being the susceptibility of the plant, a series of experiments was first carried on to ascertain the proportion of the oil that could be applied without harm to the plant. This was in the first part of September, when but very few worms were at hand.

The emulsion was first diluted with five times that amount of water, thus giving 1 part of the oil to 19 parts of milk and water; then with ten times that amount of water, and then used in still weaker dilutions. That the stronger mixture considerably scorched the plant was to be expected, but I would mention in this connection that a mixture of 1 part of kerosene to about 25 parts of water, which was incidentally applied to a few corn-stalks and cow peas, did not seem to injure those plants. The limit where the spray is less injurious to the plant begins with a mixture of about 1 part of oil to 120 parts of water, but I cannot give in exact figures the mixture that can safely be applied to the plant, as much depends on the amount of the fluid actually applied. With a small hand-atomizer the leaves nearest at hand receive a much larger amount of the fluid than those farther off, the force of the spray which strikes fullest the nearest leaves undoubtedly increasing the influence of the oil. A mixture of 1 part of the oil to 160 parts of milk and water, when moderately applied, is not injurious to the leaves. In these and the above-given figures I have not included the excess of the oil which floats on the surface of the mixture, and which I took care not to apply to the plant. How much this excess is in proportion to the amount of oil used in preparing the emulsion I had no means to determine, but the amount of oil actually applied to the plants is at any rate smaller than the figures given above. Old leaves and bolls are the least liable to be injured by the kerosene spray; very young shoots and squares somewhat more so, while young leaves fully developed and blossoms are most readily affected. In bright, hot weather the effect of the oil on the plant is visible in a few hours, dry and crisp spots appearing on the leaves, and extending more and more, according to the amount of strength of the kerosene mixture. In cloudy weather the effects are less marked, and appear much later. Another series of experiments was carried on with a view of ascertaining the minimum amount of the oil necessary to kill the worms. Pure kerosene, or strong kerosene water, when sprayed upon the worms, has very much the same effect as benzine, young worms collapsing at once and dying in less than two minutes. Old worms are not so quickly killed; they do not show any signs of pain, and die without falling into violent convulsions. The effects of diluted kerosene water on average-sized worms are not instantaneous, as with pyrethrum, but if the worms are not affected within 15 minutes after application they have either not come into contact with the oil, or the mixture was too weak to have any effect. For very young worms, *i. e.*, not over two days old (in the month of September), a very weak mixture seems to be sufficient, but with the growth of the worms the resisting power is considerably increased. The mixture of 1 part of the oil to 160 parts of water is not sufficient to kill the average-sized worm, if applied in very fine spray and in moderate quantity; that of 1 part of oil to 120 parts of water is sufficient to kill the worms, but in all cases where I applied this mixture so as to kill the worms the leaves were considerably injured.

The improvement made in the atomizing machines, which obviates entirely the danger of clogging, suggests another method to lessen the injurious influence of the kerosene on the plant, viz., by the addition of a quantity of very finely sifted wood ashes to the kerosene water, the

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idea being that the excess of the oil on the surface of the leaves would be taken up by the ashes, and thus prevented from entering into the system of the plant, while at the same time the ashes would not interfere with the effect of the oil upon the worms.

The following account of Dr. Neal's experiments with improved kerosene emulsions is from his report, published in Bulletin 1 of the Entomological Division:

As directed, I have confined my experiments to emulsions of kerosene, and noted the effects of applications of such solutions upon the cotton-plants and Cotton Worms.

My efforts were made to determine: 1. Substances best adapted to emulsify kerosene; 2. Maximum dilution of kerosene destructive to the larvæ; 3. Minimum dilution of kerosene destructive to the cotton-plants.

It was soon apparent that kerosene could not be used to advantage simply with water, from its tendency to collect at the top; nor if the water were made slightly alkaline or acid would much benefit be observed.

A strong solution of various soaps made a good emulsion, presenting some points of advantage.

Soda soap, potash soap, whale-oil soap, and other varieties were tried, but a cheap grade of yellow bar-soap, especially one in which rosin was largely used, proved best, and suggested the manufacture of a soap containing a still larger quantity of rosin, which could be cheaply sold for this purpose.

After many trials I found that 4 pounds of this soap to 1 gallon of hot water would emulsify 1 gallon kerosene, forming a gelatinous compound that was quite stable.

Less than this percentage of soap acted badly with kerosene, and a greater amount did not appear to emulsify a large amount of kerosene.

This mixture, containing 50 per cent. kerosene and costing 26 cents per gallon, I adopted as a standard.

I prepared the following dilutions:

A. One gallon standard solution to 24 gallons water, 2 per cent. kerosene, cost 1.04 cents per gallon.

B. One gallon standard solution to 39 gallons water, 1.25 per cent. kerosene, cost 0.65 cents per gallon.

C. One gallon standard solution to 49 gallons water, 1 per cent. kerosene, cost 0.52 cents per gallon.

D. One gallon standard solution to 79 gallons water, 0.625 per cent. kerosene, cost 0.325 cents per gallon.

E. One gallon standard solution to 99 gallons water, 0.5 per cent kerosene, cost 0.26 cents per gallon.

Emulsions A, B, and C presented a milky color, and were quite permanent; D and E showed some tendency to disintegrate after four days' standing.

I tried solutions of many native plants, and found the zamia finely adapted for an emulsion, especially when used immediately.

Six pounds of zamia "roots" were washed and grated. The pulp boiled an hour in 3 gallons of water; then strained, and while hot stirred in 4 ounces sal-soda. This emulsified 1 gallon kerosene, forming a beautiful pinkish jelly, containing 25 per cent. kerosene, costing 6 cents per gallon. One gallon of this solution was added to 24 gallons of water. This emulsion contained 1 per cent. kerosene, and cost 0.24 cents per gallon.

Dextrine, starch, flour, mucilage of bene (sesamum) leaf, mucilage of root of *Pteris aquilina*, and other substances were tried, but proved to be of little value.

Milk emulsions.—By gradually adding, with agitation, one gallon kerosene to one gallon fresh milk, an elegant emulsion was formed that bore dilution well, but as fresh milk is often not attainable the condensed milk was used, and the following seemed most easily made:

One part condensed milk dilute with five parts water; to this add gradually eight

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parts kerosene, with vigorous agitation. When the kerosene disappears, add three parts water, and agitate till a homogeneous emulsion is formed.

This is more pleasant to use than soapy solutions, and costs—

	Cents per gallon.
Standard solution, 50 per cent. kerosene	22
Dilution A′, 2 per cent. kerosene	0.88
Dilution B′, 1.25 per cent. kerosene	0.55
Dilution C′, 1 per cent. kerosene	0.44
Dilution D′, 6.25 per cent. kerosene	0.225
Dilution E′, 5 per cent. kerosene	0.22

The A′ and B′ were not stable longer than two days; the remaining dilutions barely one day.

With the exception of the zamia emulsion, all others were better to use the day of manufacture.

A mixture called murvite was sent me for trial. It gave similar results to the milk emulsions, when diluted in a corresponding manner.

Effects upon the Cotton-plant.—These varied greatly, owing to the weather subsequent to the application.

Emulsions A and B, A′, B′, 1½ to 2 per cent. kerosene, did not harm the cotton-plant if two cloudy or showery days followed their use. A bright sunny day scorched the tips and edges of the tender leaves badly.

Emulsions C, D, and E, C′, D′, E′, produced no bad results upon leaves or bolls, and were repeatedly tried, with uniform effects.

Effects upon Larvæ.—1. I colonized five hundred full-grown larvæ upon five cotton-plants, and sprayed them with emulsion A, soap series. In five minutes forty larvæ dropped off the plants, trembled, and soon died; in an hour but one hundred remained, none feeding, all hanging from the stems and leaves; in three hours but eight survived; the next day all were dead, and the cotton-leaves badly withered.

2. I prepared forty gallons of solution B′, milk, and sprinkled thoroughly one-fourth acre of cotton. The stalks average 7 feet in height, and the worms were very plentiful.

The next day apparently but one in each hundred was living; the day following that the difference was quite marked, and at this time, three weeks afterward, the surrounding cotton is defoliated, the sprinkled section remaining vigorous and green.

3. I colonized one hundred larvæ, all ages, on a cotton-plant; sprayed these with solution C′, milk, fifteen worms fell off in twenty minutes; the remainder quit feeding. The next morning but two remained, feebly alive.

4. One hundred large larvæ were colonized and sprayed with solution D′, milk. In ten minutes ten dropped off; in half an hour but thirty-five showed vitality; in four hours all were dead.

5. One hundred larvæ, small size, were sprayed with the one per cent. kerosene-zamia emulsion; all died within an hour.

6. One hundred small larvæ sprayed with emulsion B, soap, died in one hour.

7. Three hundred large larvæ were sprayed with solution C′, milk. The next day but twelve showed signs of life, and they were evidently moribund.

8. Three hundred large larvæ were sprayed with the zamia emulsion; all died within four hours, and the repetition of experiment 3 with this solution gave better results than with milk or soap emulsions, the zamia perhaps contributing some toxic action.

I repeated these experiments with all the emulsions till satisfied that an emulsion of one per cent. kerosene, thoroughly applied, was fatal to all larvæ it reached, and harmless to the cotton-plant.

I noted that as soon as sprinkled the small larvæ stopped eating, straightened, and quickly fell to the ground. Older larvæ would tremble, evacuate fæces, and hang suspended some time. The anal extremity lived longest.

The addition of one pound sulphide of potassium to forty gallons of any emulsion seemed to increase the rapidity of its toxic action, but it is objectionable as to smell and its destructive action upon rubber hose.

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The sulphides will bear further study.

Still, with all these emulsions, their cheapness and safety, I have a grave doubt as to the applicability of any to long-staple cotton.

I tried a number of experiments to determine the minimum quantity needed to thoroughly spray an acre of cotton during August or September. In one very carefully conducted experiment I found most of the plants averaged 6 feet high, in rows of 4 feet apart, and 2 feet between the plants in the drill.

In this case 160 gallons barely sufficed for one-half an acre, and as it could not be applied from a cart it was hand-carried. Two field hands required four hours to complete the experiment.

The labor of preparing solutions, and for carrying and using a fountain pump, will prevent small farmers, especially colored people, from trying these remedies.

The cost of this experiment was, 160 gallons solution C′, 70 cents; labor, 60 cents, or $2.60 per acre, and with the close margin between profit and expense in cotton-growing, this slight cost will deter many.[49]

We hardly need to add that Dr. Neal's method of application has been very crude and wasteful. Instead of barely reaching over one-half acre the 160 gallons of diluted emulsion ought to suffice for at least five acres, and his estimates of cost are of course much exaggerated.

OIL OF CREOSOTE.

This cheap material has lately been recommended to us as an insecticide, but we have had no opportunity so far to try it on the Cotton Worm. However, the experience we had with it last fall as a remedy for Cabbage Worms (Pieris and Noctuid larvæ) is by no means encouraging, one tablespoonful of the oil stirred up (after Saunders' method) in one gallon of water not being sufficient to kill the larger worms, while at the same time the spray ruined young turnip-plants.

OIL OF TAR.

This does not appear to differ essentially from the former, its effect on the plant being likewise more violent than that of kerosene. Mr. Schwarz reports the following experiment with this material:

No oil of tar could be obtained at Selma, but only a small bottle in which some of the oil had been, a few drops still adhering to the glass. The bottle was filled with water, the contents shaken up, and then applied to plants and worms by means of the parlor atomizer. I estimate the proportion of the oil to the water to be less than 1 to 300. This mixture proved deadly to every worm, but also scorched the leaves much more than kerosene. Owing to the very small quantity of the oil at hand I could not make any further experiments with still weaker solutions.

Since these two oils are not cheaper than kerosene and are inferior as insecticides, they are not likely to come into general use.

GAS-TAR WATER.

If water is left standing for several days over common gas-tar it becomes strongly impregnated with the smell of the tar, and the idea occurred to us to utilize such water against the Cotton Worm. Experi-

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ments made by Mr. Schwarz showed that such water does not injure the plant, and when liberally applied was sufficient to kill the very young worms, but had no effect on the larger worms.

Luthy & Marx's insect-powder.—This material, manufactured by Luthy & Marx, Philadelphia, might be mentioned in this connection, because one of its ingredients, judging from the smell of the powder, is tar or some allied substance. A box of the powder was sent by the above-named firm to Selma, Ala., in order that it might be tested for the Cotton Worm, and it was applied in dry form as well as stirred up in water, but had no effect, even on the very young worms. It proved equally harmless to the plant.

CARBOLIC ACID.

The fact that this is so commonly used in the South for the "Screw Worm," and as a general disinfectant, and that it is not yet employed against Aletia, is fair evidence that it has little value in this connection. Our own experience in trying it for other worms is that it has little effect on the worms when made weak enough to be harmless to the plant. Mr. Trelease has experimented with it for the Cotton Worm, and we give here his report to Professor Comstock:

> September 10, a number of gallons of water, containing from a half teaspoonful to a teaspoonful of carbolic acid per gallon, were applied with a fountain pump. This water was stirred so that the acid was suspended through it as *very* small globules. It was found to kill some caterpillars, but by no means enough to save the cotton; and, used in these proportions, it injured the cotton considerably.

COTTON-SEED OIL.

Of the various cheap vegetable oils this can be most abundantly and easily obtained in the South, where its manufacture is steadily on the increase. For this reason it recommended itself for experimentation against the Cotton Worm. Like kerosene, it can be emulsified by the aid of milk, but, being heavier than kerosene, the two ingredients mix less readily and separate easier when diluted with water than in the kerosene emulsion. In its action upon the worm it is very similar to kerosene, but a larger proportion of the cotton-seed oil is necessary to kill the average-sized worms, while in its effect upon the plant it is somewhat milder than kerosene. This circumstance renders cotton-seed oil (and, in all probability, all heavy vegetable oils) inferior to kerosene as an insecticide, at least in regard to this Cotton Worm question, and experiments with it were discontinued as soon as this inferiority was recognized. It occurred to us that by making a soap by using this oil and the ashes from cotton-seed hulls, which are so generally used for fuel in the manufacture of cotton-seed oil, we might obtain a liquid that could be sprayed upon the plant with good effect, thus, on the principle *similia similibus curantur*, employing the products of the plant itself as an antidote to its worst enemy, these products

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being easily obtainable at nominal cost at all points where cotton-seed oil and cake are being manufactured. The experiments made by Mr. Schwarz certainly show that there is a possibilty of successfully utilizing these materials where they can be abundantly and cheaply obtained. A strong suds from this soap was found to destroy the young worms, but seems to have little effect on the larger or full-grown ones. In this respect it acted very much as any other strong soapsuds would, and it cannot be said to have any advantage over other saponaceous compounds except in the cheapness and abundance of materials at command by planters in the vicinity of cotton-seed oil factories.

VEGETABLE INSECTICIDES.

PYRETHRUM.

HISTORY OF PYRETHRUM.—There are very few data at hand concerning the discovery of the insecticide properties of pyrethrum. The powder has been in use for many years in Asiatic countries south of the Caucasus Mountains. It was sold at a high price by the inhabitants, who successfully kept its nature a secret until the beginning of this century, when an Armenian merchant, Mr. Jumtikoff, learned that the powder was obtained from the dried and pulverized flower-heads of certain species of Pyrethrum growing abundantly in the mountain region of what is now known as the Russian province of Transcaucasia. The son of Mr. Jumtikoff began the manufacture of the article on a large scale in 1828, after which year the pyrethrum industry steadily grew, until to-day the export of the dried flower-heads represents an important item in the revenue of those countries.

Still less seems to be known of the discovery and history of the Dalmatian species of Pyrethrum (*Pyrethrum cinerariæfolium*), but it is probable that its history is very similar to that of the Asiatic species. At the present time the Pyrethrum flowers are considered by far the most valuable product of the soil of Dalmatia.

There is also very little information published regarding either the mode of growth or the cultivation of pyrethrum plants in their native home. As to the Caucasian species, we have reason to believe that they are not cultivated, at least not at the present time, statements to the contrary notwithstanding.* The well-known Dr. Gustav Radde, director of the Imperial Museum of Natural History at Tiflis, Transcaucasia, who is the highest living authority on every thing pertaining to the natural history of that region, wrote us recently as follows: "The only species of its genus, *Pyrethrum roseum*, which gives a good, effective insect powder, is nowhere cultivated, but grows wild in the basal-alpine zone of our mountains at an altitude of from 6,000 to 8,000 feet." From this it appears that this species at least is not cultivated in its native

*Report Comm. Patents for 1857, Agriculture, p. 130.

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home, and Dr. Radde's statement is corroborated by a communication of Mr. S. M. Hutton, vice-consul-general of the United States at Moscow, Russia, to whom we applied for seed of this species. He writes that his agents were not able to get more than about half a pound of the seed from any one person. From this statement it may be inferred that the seeds have to be gathered from the wild and not from the cultivated plants.

As to the Dalmatian plant, it is also said to be cultivated in its native home, but we can get no definite information on this score, owing to the fact that the inhabitants are very unwilling to give any information regarding a plant the product of which they wish to monopolize. For similar reasons we have found great difficulty in obtaining even small quantities of the seed of *P. cinerariæfolium* that was not baked, or in other ways tampered with, to prevent germination. Indeed, the people are so jealous of their plant that to send the seed out of the country becomes a serious matter, in which life is risked.

CULTIVATION OF PYRETHRUM.—The seed of *Pyrethrum roseum* is obtained with less difficulty, at least in small quantities, and it has even become an article of commerce, several nurserymen here, as well as in Europe, advertising it in their catalogues. The species has been successfully grown as a garden plant for its pale rose or bright pink flower-rays. Mr. Thomas Meehan, of Germantown, Pa., writes us: "I have had a plant of *Pyrethrum roseum* in my herbaceous garden for many years past, and it holds its own without any care much better than many other things. I should say from this experience that it was a plant which will very easily accommodate itself to culture anywhere in the United States." Peter Henderson, of New York, another well-known and experienced nurseryman, writes: "I have grown the plant and its varieties for ten years. It is of the easiest cultivation, either by seeds or divisions. It now ramifies into a great variety of all shades, from white to deep crimson, double and single, perfectly hardy here, and I think likely to be nearly everywhere on this continent." Dr. Barnard reports that "in the garden of the Starling plantation, on Lake Chicot, at Sunny Side, Ark., I found Pyrethrum which had been growing perennially for many years. This is toward the northern limit of the cotton belt and, for the river country, the most northern point of serious injuries from the Cotton Worm. Since the plant does not freeze out there it will certainly withstand the winter throughout the region of serious depredation from the worm." Dr. James C. Neal, of Archer, Fla., has also successfully grown *Pyrethrum roseum* and many varieties thereof, and other correspondents report similar favorable experience. None of them have found any special mode of cultivation necessary. In 1856 Mr. C. Willemot made a serious attempt to introduce and cultivate the plant[50] on a large scale in France. As his account of the cultivation of Pyrethrum is the best we know of, we quote here his experience with but few slight omissions: "The soil best adapted to its culture should be

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composed of a pure ground, somewhat siliceous and dry. Moisture and the presence of clay is injurious, the plant being extremely sensitive to an excess of water, and would in such case immediately perish. A southern exposure is the most favorable. The best time for putting the seeds in the ground is from March to April. It can be done even in the month of February if the weather will permit it. After the soil has been prepared and the seeds are sown they are covered by a stratum of ground mixed with some vegetable mold, when the roller is slightly applied to it. Every five or six days the watering is to be renewed in order to facilitate the germination. At the end of about thirty or forty days the young plants make their appearance, and as soon as they have gained strength enough they are transplanted at a distance of about six inches from each other. Three months after this operation they are transplanted again at a distance of from fourteen to twenty inches, according to their strength. Each transplantation requires, of course, a new watering, which, however, should only be moderately applied. The blossoming of the Pyrethrum commences the second year, toward the end of May, and continues to the end of September." Mr. Willemot also states that the plant is very little sensitive to cold, and needs no shelter, even during severe winters.

The above quoted directions have reference to the climate of France, and as the cultivation of the plant in many parts of North America is yet an experiment, a great deal of independent judgment must be used. The plants should be treated in the same manner as the ordinary Asters of the garden or other perennial Compositæ.

As to the Dalmatian plant, it is well known that Mr. G. N. Milco, a native of Dalmatia, has of late years successfully cultivated *Pyrethrum cinerariæfolium* near Stockton, Cal., and the powder from the California-grown plants, to which Mr. Milco has given the name of "Buhach," retains all the insecticide qualities and is far superior to most of the imported powder, as we know from experience. Mr. Milco gives the following advice about planting—advice which applies more particularly to the Pacific coast: "Prepare a small bed of fine, loose, sandy, loamy soil, slightly mixed with fine manure. Mix the seed with dry sand and sow carefully on top of the bed. Then with a common rake disturb the surface of the ground half an inch in depth. Sprinkle the bed every evening until sprouted; too much water will cause injury. After it is well sprouted, watering twice a week is sufficient. When about a month old weed carefully. They should be transplanted to loamy soil during the rainy season of winter or spring."

Our own experience with *Pyrethrum roseum* as well as *Pyrethrum cinerariæfolium* in Washington, D. C., has been so far quite satisfactory. We have observed that the seed often lies a long time in the ground before germinating, and that it germinates best when not watered too heavily. We think that the too rapid absorption of moisture often causes the

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seed to burst prematurely and rot, where slower absorption in a soil only tolerably moist affords the best conditions for germination.

The seed of both species sown, whether in the fall of 1880 or in the spring of 1881, germinated tolerably well, though some was evidently worthless when received. A few plants of *roseum* from that sown in the fall of 1880, bloomed the ensuing autumn, while all sown in the spring of 1881 bloomed profusely the following summer.

Both species withstood the winters very well, and as these were extreme winters, the one very severe and cold, the other open and mild, the test may be considered a very thorough one. The older leaves died off, as is the custom with many allied perennial species, but the plants began growing very early in spring and were, in fact, among the vernal adornments of the garden. *Roseum* began blooming early in May, and showed every variation in color from almost pure white to deep crimson. It also showed considerable variation in the green of the leaves as well as in the form, some plants having the leaves much more finely cut than others. *Cinerariæfolium* which has a much smaller flower, with pure white petals, very strongly resembling the common Ox-eye Daisy, began blooming a month after *roseum* had passed its prime. It proved uniform in color, and is always distinguishable from *roseum*, even before blooming, by the whitish or glaucous green of the leaf, and its much deeper and broader incisions.

A portion of the flower heads were dried and pulverized, the powder proving to be fully equal in efficacy to the imported article; while the powder from dried stems and leaves is decidedly weaker, but still useful when applied in large quantities.[51]

PREPARATION OF THE PLANTS FOR USE.—In regard to manufacturing the powder, the flower heads should be gathered during fine weather, when they are about to open, or at the time when fertilization takes place, as the essential oil that gives the insecticide qualities reaches, at this time, its greatest development. When the blossoming has ceased the stalks may be cut within about four inches from the ground and utilized, being ground and mixed with the flowers in the proportion of one-third of their weight. Great care must be taken not to expose the flowers to moisture, or the rays of the sun, or still less to artificial heat. They should be dried under cover and hermetically closed up in sacks or other vessels to prevent untimely pulverization. The finer the flower heads are pulverized the more effectually the powder acts and the more economical is its use. Proper pulverization in large quantities is best done by those who make a business of it and have special mill facilities. Lehn & Fink, of New York, have furnished us with the most satisfactory powder. For his own use the farmer can pulverize smaller quantities by the simple method of pounding the flowers in a mortar. It is necessary that the mortar be closed, and a piece of leather through which the pestle moves, such as is generally used in pulverizing pharmaceutic substances in a laboratory, will answer. The quantity to be

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pulverized should not exceed one pound at a time, thus avoiding too high a degree of heat, which would be injurious to the quality of the powder. The pulverization being deemed sufficient, the substance is sifted through a silk sieve, and then the remainder, with a new addition of flowers, is put in the mortar and pulverized again.

The best vessels for keeping the powder are fruit jars with patent covers, or any other perfectly tight glass vessel or tin box.

THE USE OF PYRETHRUM AS AN INSECTICIDE.—Up to a comparatively recent period the powder was applied to the destruction of those insects only which are troublesome in dwellings, and Mr. C. Willemot seems to have been the first, in the year 1857 (?), to point out its value against insects injurious to agriculture and horticulture. He goes, however, too far in his praise of it, and some of his statements as to its efficacy are evidently not based upon actual experiment. Among others he proposes the following remedy: "In order to prevent the ravages of the weevil on wheat fields, the powder is mixed with the grain to be sown, in proportion of about ten ounces to about three bushels, which will save a year's crop." This is simply ridiculous, as every one who is familiar with the properties of Pyrethrum will understand. We have during the past few years largely experimented with it on many species of injurious insects, and fully appreciate its value as a general insecticide, which value has been greatly enhanced by the discovery that it can be most economically used in liquid solution; but we are far from considering it a universal remedy for all insects. No such universal remedy exists, and Pyrethrum has its disadvantages as has any other insecticide now in use. The following are its more serious disadvantages: (1) the action of the powder, in whatever form it may be applied, is not permanent in the open air. If *e.g.*, it is applied to a plant, it immediately affects the insects on that plant with which it comes in contact, but it will prove perfectly harmless to all insects which come on the plant half an hour (or even less) after the application; (2) the powder acts in the open air—unless, perhaps, applied in very large quantities—only upon actual contact with the insect. If, *e.g.*, it is applied to the upper side of a cotton leaf the worms that may be on the under side are not affected by it; (3) it has no effect on insect eggs, nor on pupæ that are in any way protected or hardened.

These disadvantages render Pyrethrum in some respects inferior to arsenical poisons, but, on the other hand, it has the one overshadowing advantage that it is perfectly harmless to plants or to higher animals; and if the cultivation of the plants in this country should prove a success, and the price of the powder become low enough, the above mentioned disadvantages can be overcome, to a certain degree, by repeated applications.

It is to Prof. E. W. Hilgard, of the University of California, that we

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owe the first accurate determination of the destroying principle in Pyrethrum. He wrote us as follows on this subject:

I have had Milco's product in hand for some time, and have tried it on various bugs both in powder and infusion. To understand the best manner of using it in each case, it must be kept in mind:

1. That the active substance is a volatile oil.

2. That said oil, under the influence of air, not only volatilizes, but is also oxidized, and thereby converted into an inert resin.

It follows from 1 that the pyrethrum is at a disadvantage when used in the shape of powder in the open air, especially when the wind blows; from 2 that it is of the greatest importance that the substance should be fresh, or should have been kept tightly packed, for the same reason that hops must be similarly treated.

Hence I find that Milco's fresh powder is of greater efficacy than the best imported, although some of the latter contains twice as much matter soluble in ether; but the extract from the "buhach" is a clear greenish oil, while that from imported powder, and especially that from "Lyon's magnetic"—ground-up refuse, stems, &c., as I take it—is dark and thickish, or almost dry and crumbly.

The real nature of the effect of this volatile oil on insect life has not yet been studied, and still remains obscure. Different species of insects are differently affected by the powder, but since no other animals are affected so far as we yet know in anything like the same degree, it may be inferred that with insects those organs are affected which are essentially characteristic of them, viz., those connected with respiration. Some insects resist the action of the powder to quite a marked degree, *e. g.*, very hairy caterpillars, and especially spiders of all kinds; while others, especially all Hymenoptera, succumb most readily. In no case are the insects killed instantaneously by Pyrethrum. They are rendered perfectly helpless a few minutes after the application, but do not die till some time afterward, the period varying from several hours to two or even three days, according to the species. Many insects that have been treated with Pyrethrum show signs of intense pain, while in others the outward symptoms are much less marked.

The effect of Pyrethrum on the Cotton Worm may be described as follows: The worm becomes uneasy in from 5 to 20 seconds after the application, according to the amount of Pyrethrum applied, and, again, according to the size of the worm. Very shortly afterward it attempts to bite off or to remove the particle or particles of the powder adhering to its body, during which operation a greenish juice emanates from its mouth. Its motions become more and more violent, until at last, within from 4 to 10 minutes, the whole body is thrown into convulsions, the worm having lost all control over itself. These convulsions continue for many hours, the worm getting weaker and weaker until death ensues. Small worms die in about 3 or 4 hours; half-grown ones often not before 24 hours have elapsed. Full-grown worms are not easily affected, and generally recover from the effects of even a pretty strong dose of Pyrethrum, while very young worms are most readily affected even by a very

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weak dose. If the dose is not strong enough, the convulsions of the worm are much less violent, and it recovers fully within a few hours.

The action of the poison depends, however, less upon the amount of powder used than upon the part of the body of the worm which it touches, and on the method of applying it. Very small particles placed upon the sides of larvæ, especially near the anterior spiracles, produce a more marked effect than larger quantities dropped upon their backs or lodged among the hairs. The effect is also enhanced by driving the powder with force against the worms by means of a bellows, for example, as the particles are thus driven into closer contact.

After the preliminary trials made in 1878, and the more extensive ones made in 1879, the encouraging results of which are recorded in the first edition of this work (pp. 62–64), we had the experiments vigorously continued by the agents of the Commission in subsequent years, and at various points within the cotton belt. These experiments were made partly with buhach kindly furnished by Mr. G. N. Milco, of Stockton, Cal., partly with imported insect powder made from *Pyrethrum roseum*, and which had been liberally placed at the disposal of the Commission by Messrs. Lehn & Fink, of New York. There seems to be but little difference in efficacy between these two kinds of powder. To test their relative strength, Mr. H. G. Hubbard made the following experiment:

"Sixty Cotton Worms were collected and divided into two lots as equally as possible, so that neither set should contain an undue proportion of old or young worms. Each set was placed in a Mason jar, and thoroughly dusted with a small quantity of powder, one jar with the buhach, and the other with the imported pyrethrum. The worms were immediately afterwards turned out upon newspapers spread upon the ground. Those dusted with buhach were paralyzed and unable to crawl about in from 15 to 20 minutes. Those treated with imported pyrethrum were similarly affected in from 25 to 30 minutes. In both lots the worms began to be affected in less than one minute, and nearly all died within 12 hours. Another experiment was made upon 100 worms of all sizes in which the powder (imported) was applied in the open air by means of a bellows. Worms one-fifth to one-third grown were completely paralyzed in 10 minutes; worms one-half grown, in 30 to 45 minutes; full-grown worms showed the full effect of the poison after several hours. In about three hours the smaller worms appeared to be dead. The oldest worms did not die before night."

Pyrethrum can be applied—1, as a dry powder; 2, as a fume; 3, as an alocholic extract diluted; 4, by simple stirring of the powder in water; 5, as a tea or decoction.

1. APPLICATIONS OF PYRETHRUM AS DRY POWDER.—The following experiments were made by Mr. Hubbard at Centreville, Fla., to ascertain the minimum quantity of the dry powder that could be used with effect

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upon very young Cotton Worms, the powder experimented with being the Californian buhach:

All the larvæ experimented with were hatched last night (August 10) from eggs laid in breeding jar during the night of August 7, except larva (*n*) which was only a few hours from the egg.

(*a*) Three minute fragments of pyrethrum laid upon back (terminal half of body) with the point of a needle; larvæ affected in 15 seconds; convulsed in 1 minute and 15 seconds; died in p. m.

(*b*) One minute fragment applied on back (anterior segments); fragment dropped off in 3 minutes; probably only adhered to hairs of body 3½ minutes; larva appeared affected but slightly; after three hours larva appears to have recovered; p. m., went to eating and fully recovered. This is a very vigorous larva, probably several hours older than the rest. (August 12, has grown larger and is eating well.)

(*c*) One almost microscopic fragment applied with needle-point to side near spiracles; evidently affected in fifteen seconds; convulsed in 1½ minutes. Fragment adhered 1 minute. Larva died in p. m.

(*d*) One very minute fragment (almost microscopic fragment) applied on side of body near middle. Larva lost sight of during 4 minutes, at end of which time was entirely convulsed. Died in p. m.

(*e*) Several (three or four) small fragments applied on side of body; affected in 30 seconds; convulsed after 2 minutes, 15 seconds. Died in p. m.

(*f*) One minute fragment on middle of back; affected in 1 minute, 15 seconds; convulsed in 3 minutes; fragment dropped off in 3 minutes. Four o'clock p. m., larva recovering; later, went to eating; entirely restored. (August 12, alive and well.)

(*g*) One microscopic fragment on back at anal extremity of body and very soon lost off (20 seconds?). Seemed affected after 5 minutes; examined after 2 hours; seems not injured. In p. m. entirely well—see (*g*) below.

(*h*) One large fragment (size of "blow-fly" egg) applied for 5 or 6 seconds to side of body, near or upon spiracles; affected in 2 minutes; convulsed in 4 minutes; 2 hours, unable to move about; 4.30 p. m., still alive but disabled. Died before night.

(*i*) One entirely microscopic fragment applied to back of neck; affected in 1½ minutes; convulsed in 3 minutes; 4.30 p. m., appears recovering. (August 12, larva died this morning.)

(*k*) One entirely microscopic fragment applied underneath anterior segments between legs; adhered only a few seconds; appears affected after 15 minutes, but able to move about; 4.30 p. m., recovering and eating; later, fully recovered. (August 12, alive and well.)

NOTE.—Larvæ (*l*) (*m*) and (*n*) were treated as follows: A small quantity of pyrethrum placed on a piece of paper was lightly sprayed with an atomizer, and allowed to remain covered with drops of moisture for about ten minutes. The larvæ were then touched with a needle dipped in this poisoned dew.

(*l*) A single, very slight, and probably insufficient application beneath anterior segments; no moisture adhered to larva; affected after 1 minute, 15 seconds; 1 hour later appears torpid, but not convulsed; 4 p. m., recovered and eating. (August 12, alive and well.)

(*m*) Touched with poisoned dew about anterior segments and moisture left upon back of the segment, more thoroughly applied than in preceding larva; affected in 45 seconds; convulsed in 2 minutes; 4.30 p. m., recovered. (August 12, alive and well.)

(*n*) A very young larva, probably hatched late this morning, was allowed to crawl along needle and over a drop of poisoned dew; instantly affected; convulsed in 15 seconds. Died in p. m.

(*g*) Second experiment with larva (*g*) made in p. m. One fragment (size of "blow-fly" egg) laid on back, middle of body, not touching the skin, but adhering to hairs; dropped off in 30 seconds; evidently affected in 45 seconds; completely convulsed in 2 minutes. Died in few hours.

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The practical application of such minute quantities in the open field is out of the question, and so is the use of the undiluted powder on a large scale, so long as its price is much higher than that of common flour. Mr. Hubbard continues:

Experiments in the fields with the dry powder sifted upon the plants gave very unsatisfactory results unless large quantities of the powder were used. On August 28, a very windy day, I tried an application with the bellows, allowing the wind to carry the powder in fine clouds through the foliage, and using about one pound to the acre. In this way, owing partly to the impossibility of securing an equal distribution, some worms were affected at a distance of ten or fifteen feet, while others, much nearer, were not affected at all. I have reason to believe that very few worms were killed outright at this trial. Some recovered in a few hours. A number of those which showed signs of pain, but had been very lightly dusted, I confined in vivaria, and all completed their transformations in the usual time. At the time the foregoing experiment was made the leaves were quite wet with recent rain, and another heavy shower occurred later in the day.

Prof. J. P. Stelle carried out, during his stay at Calvert, Texas, similar experiments with the same amount of undiluted powder and with the same unsatisfactory results. Fortunately it has been found that if unadulterated and fresh (which cannot be said in many instances of the powder sold at retail by our druggists) it may be considerably diluted with other pulverized material without losing its deadly effect, the use of the powder thus becoming much cheaper. Of the materials which can be used as diluents, common flour seems to be the best, but finely-sifted wood-ashes, sawdust from hard wood, &c.—in short, any light and finely pulverized material which mixes well with the pyrethrum powder—will answer the purpose.

It has also been found that if the mixture of Pyrethrum and flour is applied immediately after preparation it is always weaker in effect than when left in a perfectly tight vessel for at least twenty-four hours before use. In the experiments made in 1879 we found that a mixture of one part of Pyrethrum with ten parts of flour, applied immediately after preparing, is sufficient to kill the average-sized worms with which it comes in contact; and that the mixture of one part of the powder to sixteen parts of flour is equally efficient after being kept for some days in a tight glass jar. The experiments made subsequently do not alter these results to any considerable extent. It would be quite superfluous to mention here the experiments made with very strong mixtures of Pyrethrum and flour, since they add nothing new to our experience, and we shall refer rather to those which were made to ascertain the minimum quantity of the powder necessary. The following series of experiments was made at Selma, Ala., by Mr. Schwarz:

Experiment 1, August 27.—Pyrethrum powder, one part, mixed with twenty parts of flour, applied with the sieve immediately after preparing. Worms mostly more than half-grown. Only a small proportion of the worms came in contact with the mixture, though it was applied toward evening. These worms were affected within the usual time, but upon examination, about ten hours afterwards, much more than half the number had recovered. The mixture in this proportion, and applied with the sieve, is evidently a failure.

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Experiment 2, August 27.—The same mixture applied with the bellows while going slowly between the rows. A large proportion (estimated at two-thirds) of all the worms on the plants were affected, but most of them had recovered the next morning.

Experiment 3, August 27.—The same mixture applied with the hand. I had seen this method in use in Texas, where flour and Paris green were used, and convinced myself that it was an excellent and very economical method of applying dry powders to high plants. I found, however, to-day that it requires some practice to distribute the mixture evenly and economically. The result was about the same as in Experiment No. 2. The mixture is evidently too weak if applied in moderate quantity.

Experiment 4, September 4.—Pyrethrum 1 part, mixed with 10 parts of flour, applied immediately after preparing, by means of the bellows. Comparatively few worms on the plants, and no very young ones. Again, about two-thirds of the worms affected, of which none or very few recovered. This mixture is evidently strong enough to kill all the worms with which it comes in contact, though it was distributed in small quantity.

Experiment 5, September 4.—Pyrethrum 1 part, mixed with 15 parts of flour, applied with the bellows, in part thickly, *i. e.*, walking very slowly and using the bellows freely, and in part very slightly applied. In the former case the mixture is as efficient as that mentioned in Experiment 4, about two-thirds of the worms being killed; in the latter case a great proportion of the worms recovered.

Experiment 6, September 5.—Finely-sifted wood-ashes were substituted for the flour; ratio, 1 part pyrethrum to 10 parts of ashes. Applied with the bellows. Effect the same as in Experiment 4. The mixture is much lighter than flour, and spreads more, but for this reason is not useful in windy weather; moreover, the preparation of the wood-ashes is somewhat troublesome, as they must be sifted through a very fine sieve.

Experiment 7, September 21.—Finely-sifted prairie soil was substituted for the flour; 1 part of pyrethrum to 10 parts of soil. The mixture could not be applied by means of the bellows, as it is too heavy; neither can it be applied by means of the sieve, as the two materials separate at once, the powder coming to the surface. It was finally applied by throwing it with the hand, but it is evident that even then it is inferior to flour and ashes, owing to its weight, which prevents its spreading and flying about like the much finer and lighter flour. Otherwise, the mixture acts as powerfully as that of pyrethrum and flour mixed at the same rate.

Experiment 8, September 21.—The same mixture as in experiment No. 1 applied after it was left standing in a tight glass jar ever since August 27. Applied in moderate quantity by means of the bellows. Worms very plentiful and mostly small. Again, about two-thirds of the worms were affected, of which only a small proportion, if any, recovered. The mixture is evidently by far stronger now than when freshly prepared, and would undoubtedly be strong enough for average-sized worms.

Experiment 9, September 26.—A small remnant of the mixture used in experiment No. 8, which had been diluted, September 21, with about one-half the amount of flour, was applied by means of the bellows. Worms very plentiful, and of all sizes. When applied thickly the mixture still kills the small worms; the larger ones that were affected had, with few exceptions, all recovered the next day. When applied slightly, even a portion of the smaller ones recovered; very small worms were, however, still destroyed.

N. B.—Full-grown worms are not taken into consideration in these experiments, as they usually recover, unless they get a very large dose of the mixture. A number of trials in and out doors proved that for newly-hatched worms a mixture of one part of pyrethrum to 20 parts of flour applied slightly and immediately after preparing is amply sufficient. In these experiments, I used both the Californian buhach and imported insect powder (furnished to the Commission by Messrs. Lehn & Fink), without noticing any difference in efficacy between the two.

Prof. R. W. Jones obtained very similar results. He writes, "One part of Pyrethrum to 20 parts of wheat flour, thoroughly mixed and

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shut up in a tight tin box for 24 hours. This, blown by bellows, proved very efficient in destroying Aletia larvæ which it touched."

While it is thus proved that one part of Pyrethrum mixed with ten parts of flour and applied immediately after preparing, or the same amount of Pyrethrum to twenty parts of powder, applied after being kept in a tight vessel for some time, is sufficient to kill the average-sized worms, the problem yet remained to apply this mixture so that it would touch all worms on the plants. That this cannot be accomplished by an application from above is apparent from the habits of the older worms to hide, during the day, on the under side of the leaves, and even if applied at night the mixture would, under the most favorable circumstances, be but partially successful, as the young worms, which do not come at all to the upper surface of the leaves, would not be killed. Application from below is therefore imperative to insure success, and suitable machines for this purpose will be described farther on. In the year 1880 we estimated that it would require one and three-quarter pounds of Pyrethrum powder to go over an acre of cotton of medium height when mixed with 20 pounds of flour. With the improved appliances the amount per acre will probably be reduced to less than one pound. The price, when the first edition of this work was published, averaged 75 cents per pound, but is much lower at the present writing.[53]

2. APPLICATION OF PYRETHRUM IN FUMES.—Whatever advantages this method may have in a closed room it is evidently impracticable on a large scale in the field, and consequently no experiments have been made.

3. ALCOHOLIC EXTRACT OF PYRETHRUM.—The not inconsiderable differences in the results obtained by the agents of the Commission while experimenting with extracts are principally due to the fact that the extracts can be obtained in various ways and of varying strength. A good extract may be obtained either by distillation or by the repercolation process. Which of the two methods is preferable it is difficult to say. The former seems, however, to more thoroughly extract the oil than the latter; but in both kinds of extract the residuum of the powder may be kept in suspension so that no particle of the strength of the powder is lost. The extract by distillation is easily obtained by taking a flask fitted with a cork and a long and vertical glass tube. Into this flask the alcohol and pyrethrum are introduced and heated over a steam tank or other moderate heat. The distillate, condensing in the vertical tube, runs back, and at the end of an hour or two the alcohol may be drained off, and the extract is ready for use.

Prof. E. A. Smith, of Tuscaloosa, Ala., found during the year 1879 that the extract thus obtained, if diluted with water at the rate of one part of the extract to 15 of water, and sprayed on the leaves, kills the worms that have come in contact with the solution in a few minutes. The mixture in the proportion of 1 part of the extract to 20 parts of water

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was equally efficacious, and even at the rate of 1 to 40 it killed two-thirds of the worms upon which it was sprayed in 15 or 20 minutes, and the remainder were subsequently disabled. In still weaker solution, or at the rate of 1 to 50, it loses in efficacy, but still kills some of the worms and disables others.

Professor Jones, of Oxford, Miss., reports his method of preparing the extract, and the results of his experiments, made in 1880, as follows:

In all my first preparations I proceeded as follows:

I introduced into a glass flask about 4 ounces of insect-powder, and added about half a gallon of alcohol; corked, and allowed to stand for 24 hours.

I then perforated the cork and introduced a glass tube, one-fourth of an inch in diameter and 36 inches long; then subjected the flask to the well regulated heat of a water-bath, not allowing the temperature to reach the boiling point of alcohol. I usually applied this gentle heat for about 5 hours; then set aside to cool. At first I decanted the extract from the residue, and, before using, diluted with water, as shown in the experiments mentioned farther on. Subsequently I shook up the solid residue of the insect-powder with the extract, and diluted the whole with water, and in applying kept the solid matter suspended by agitation. I found the latter plan economical. The residue, being wet with alcohol, readily spreads throughout the water, and evidently adds something to the value of the extract.

I have never seen any statement or suggestion in regard to the use of wood-spirit as the menstruum. It occurred to me to try it. I found it to be a quicker solvent of the essential oil and coloring matter of pyrethrum powder than common 95 per cent. alcohol. I find that 1 pint and 2 ounces (by measure) of wood-spirit will extract all the useful material out of an ounce of pyrethrum. Good wood-spirit can be bought for $1.25 per gallon.

The extract made with wood-spirit will bear dilution with a somewhat larger quantity of water than the extract made with ethyl alcohol. On this point I state my results thus:

One pound pyrethrum powder to 20 pints (2½ gallons) wood-spirit; this can be safely diluted in the earlier part of the season, when the worms are small, with 40 parts of water; hence, 1 pound pyrethrum and 2½ gallons methyl alcohol will, when diluted, make 100 gallons of liquid for the destruction of insects. Allowing 40 gallons to the acre, the cost of this insecticide would be $1.50; with improved atomizers this will be lessened.

Wood-spirit is more volatile than ethyl alcohol. This, I think, gives it considerable advantage over ethyl alcohol as the solvent for the essential oil of the pyrethrum, when the extract is to be used for Boll Worms that are working on the contents of the bolls. By its ready volatilization it distributes the insecticide rapidly into the adjacent air, and when not directly thrown into the hole cut by the Boll Worm it is carried into the chamber by rapid diffusion, and, affecting the worm, causes it to come forth from its concealment upon the moistened parts of the plants, where by the contact of the liquid it is poisoned to death. The extract made with ethyl alcohol is also volatile, and produces this same effect, though in a less degree, to the extent that its volatility is less than that of methyl alcohol. The extractive power of methyl alcohol on pyrethrum is so great that it is hardly necessary to apply any heat. The alcohol may be allowed to stand 24 hours on the powder, being shaken up a few times, and then the whole, both the extract and solid residue, may be mixed with water, so as to give 100 gallons to the pound of pyrethrum. I found that the use of the liquid is much to be preferred to the powder. It reaches all parts of the plant better, it is more easily handled, and it kills quicker.

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Another series of trials with the extract obtained by repercolation was carried on by Mr. Schwarz, at Selma, Ala., in 1880. He reports as follows:

The extract I used was prepared by Messrs. Wilkins & Brooks, druggists, at Selma, from imported insect-powder, by the repercolation process as prescribed in the American Pharmacopœia. From 1 pound of the powder 1 pint of extract was obtained, 1 drop of the extract thus representing 1 grain of the powder. The extract is a dark-brown fluid, with but a very small amount of sediment, which is very easily shaken up and does not interfere in the least with applying the fluid through very small orifices. The actual cost of preparing the extract was 50 cents. The residuum of the powder from which the extract was made was tried several weeks afterwards and did not seem to have lost much of its strength, as upon application with the insect-gun a number of pea-weevils, which were just at hand, were immediately affected. It is thus quite possible that another pint of extract of the same strength as the first could have been obtained from the same pound of powder. This must be taken in account in the results obtained by my experiments. The extract was diluted with water, and by a series of trials I found that 10 drams of the extract to 2 gallons of water, when applied with the fountain-pump or atomizer, is sufficient to kill the average-sized worms which come in contact with the fluid. Full-grown worms mostly recover, while very young worms are fatally affected by a moderate application of a mixture of 4 drams of the extract to 2 gallons of water.

The mixture of 10 drams of extract to 2 gallons of water was applied by means of the fountain-pump from above as well as from the side. There were plenty of worms mostly below average size on the plants. In the application from above, *i. e.*, imitating the common sprinkling arrangements, the liquid was very liberally used, the upper side of the leaves being entirely wet. Very many worms were affected and killed by the liquid, but a large proportion were not reached by the spray, and the application did not protect the plants, for they were denuded of leaves in the same time as those not experimented with. The same mixture was applied from the side with the fountain-pump, the liquid being also used freely at a rate which I estimated at from 60 to 70 gallons per acre, great care being taken to apply the liquid to every part of the plants. Upon examination about 14 hours afterwards only a few large worms were found on the plants, all the others being dead or dying. Numerous trials proved that the same mixture, when applied in the mist-like spray of a parlor-atomizer, is fully sufficient to kill the worms, the amount of the liquid necessary being very small. A mixture of 8 drams of the extract to 2 gallons of water was thoroughly applied to a number of plants by means of the fountain-pump. All worms on the plants were affected within the usual time, but 16 hours afterwards a considerable portion of the larger worms had recovered, and were again feeding. My experiments would thus show that 1 pint of the extract (which is equal to 1 pound of powder) could only be diluted with about 26 gallons of water, or barely sufficient to go over one acre of cotton. This would be a rather unfavorable result, considering that to the cost of the powder that of making the extract has to be added; but, as above stated, the extract I used was far from being a perfect one, or else better results would have been obtained.

Although the results obtained by Professor Jones and Mr. Schwarz do not accord with each other—a divergence which is easily explained, however, by the different extracts employed—they show sufficiently that the extract can be used more economically than the powder, a result which could not have been anticipated from the experiments made in 1879. Professor Jones estimates that 1 pound of powder converted into extract is sufficient to give 100 gallons of liquid, while

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Mr. Schwarz calculates 1 pint of extract, or 1 pound of powder, to each 26 gallons of water; but his extract costs only 50 cents in addition to the cost of the powder, while that of Professor Jones costs about $3.15 in addition to the powder. Allowing 75 cents for 1 pound of Pyrethrum and 20 gallons (with the improved atomizing machines) of fluid per acre of cotton, we arrive at a cost of 78 cents for Professor Jones's extract, made by distillation, and 96 cents for Mr. Schwarz's extract, made by repercolation. Taking into account that Mr. Schwarz's extract was not a very strong one, the real cost of the application will be nearer the former figure. Further experiments will no doubt lessen the cost of making a perfect extract, but considering the high price of the alcohol necessary to its preparation, Pyrethrum, in the form of alcoholic extract, will remain a somewhat expensive remedy. On the other hand the extract is extremely convenient to handle, and can be kept for an indefinite length of time without losing its efficacy.

5. PYRETHRUM IN SIMPLE WATER SOLUTION.—That a portion of the volatile oil contained in Pyrethrum is soluble in water, was made known in 1879 by Professor Hilgard; but that the powder simply stirred up in water would prove a most satisfactory and economical method of application was a most encouraging discovery that resulted from the experiments made at Selma in 1880. The powder is most readily stirred up in water, and the slightest disturbance or irregular movement of the vessel containing themixture is sufficient to keep the particles in suspension, owing to the very light nature of the powder. This is an important point, since it has been proved by experiment that the mixture, if applied after the powder particles have settled to the bottom, is less efficacious than when kept stirred up. It is also advisable to apply the mixture immediately or at least soon after preparing it, as it gradually loses its strength, even if kept in a tight vessel.

We had intrusted Mr. Schwarz, during his stay at Selma, Ala., with conducting experiments with Pyrethrum-water, and he reported as follows:

As I was not prepared to find this method of applying pyrethrum so efficient and economical as it proved to be, I carried on a number of experiments with a much larger proportion of the powder than I found finally to be sufficient to kill the worms. The enumeration of these preliminary experiments, in which I was constantly lowering the proportion of pyrethrum, is therefore omitted as superfluous.

After many trials I found that 200 grains of powder, stirred up in 2 gallons of water, are sufficient to kill all worms which are brought in contact with the fluid, only some of the full-grown ones recovering; that if a weaker mixture is used a portion of the average-sized worms recover; and that very young worms are fatally affected by a mixture of 100 grains of powder to 2 gallons of water.

With the mixture of 200 grains of powder to 2 gallons of water, the following four experiments were carried on by myself and Mr. Hubbard, in the latter part of September, and each repeated several times, so that but little doubt can be had regarding the correctness of the results. There were plenty of worms on the plants at the time.

Experiment 1.—Two gallons of the liquid applied by means of the fountain pump from above, thus imitating the action of any of the sprinklers now in use. The liquid

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was applied freely, the upper surface of the leaves so far as they were not protected by others above them being pretty thoroughly wetted. Results far from being satisfactory. A large number of worms were affected and killed, but a far greater proportion did not come in contact with the fluid, and were consequently not affected.

Experiment 2.—The liquid was again applied by means of the fountain pump, but from one side. In this case the jets strike the leaves and branches with considerable force, and the liquid is consequently much more scattered than in the application from above. The result was that by far the largest portion of the worms were affected and killed, but there remained enough on the plants to do serious injury.

Experiment 3.—The liquid applied as in the foregoing experiment, but from the two opposite sides. Two corners of the field were treated in this way. Result: The plants were effectually freed from the worms, and only a very few full-grown ones were found about twelve hours afterwards. I must state, however, that the amount of liquid used in this mixture was very large, estimated at the rate of not less than 80 gallons per acre.

Experiment 4.—The liquid applied by means of the parlor atomizer. This could naturally be carried on only on a very small scale, but was often repeated. The result I can draw from this experiment is that the very fine, mist-like spray of the atomizer is most effective, and even more so than a coarse and copious spray.

One pound of Pyrethrum, if used at the rate mentioned in these experiments, viz., 200 grains of the powder to 2 gallons of water, could thus be diluted with 75 gallons of water, which would be sufficient for 2½ acres of cotton, calculating 30 gallons per acre. The cost of this application (not counting in labor and machinery), consists only in that of the powder, and putting this down at 75 cents per pound, we arrive at the amount of 30 cents per acre of cotton. It must further be considered that 30 gallons of liquid per acre, applied with the improved atomizers, is a liberal allowance, and that, therefore, the cost of the application can in all probability still be lowered considerably without loss in efficacy. At any rate, this method of applying Pyrethrum is by far cheaper and simpler than any other at present known to us. It is of course not free from the principal drawback of Pyrethrum as an insecticide, and a repeated application is necessary to protect the cotton from one generation of worms. But even this double application is cheaper than the dry Paris-green remedy, as carried on by the sifting method.

5. THE TEA OR DECOCTION OF PYRETHRUM.—Professor Hilgard, who first called our attention to this method of using Pyrethrum, expresses himself most favorably as to the results of this experiment. He says:

I think, from my experiments, that the *tea or infusion prepared from the flowers* (which need not be ground up for the purpose) is the most convenient and efficacious form of using this insecticide in the open air; provided that it is *used at times when the water will not evaporate too rapidly*, and that it is applied, not by pouring over in a stream, or even in drops, but *in the form of a spray from a syringe* with *fine* holes in its rose. In this case the fluid will reach the insect despite of its water-shedding surfaces, hairs, &c, and stay long enough to kill. Thus applied, I have found it to be efficient even against the armored scale-bug of the orange and lemon, which falls off in the course of two or three days after the application, while the young brood is almost instantly destroyed. As the flower tea, unlike whale soap and other washes, leaves the leaves perfectly clean and does not injure even the most tender growth, it

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is preferable on that score alone; and in the future it can hardly fail also to be the cheaper of the two. This is the more likely, as the tea made of the leaves and stems has similar, although considerably weaker, effects; and if the farmer or fruit-grower were to grow the plants, he would save all the expense of harvesting and grinding the flower-heads by simply using the header, curing the upper stems, leaves, and flower-heads all together, as he would hops, making the tea of this material by the hogshead, and distributing it from a cart through a syringe. It should be diligently kept in mind that the least amount of *boiling* will seriously injure the strength of this tea, which should be *made* with briskly boiling water, but then simply covered over closely, so as to allow of as little evaporation as possible. The details of its most economical and effectual use on the large scale remains, of course, to be worked out by practice.

Having no sufficient supply of flower-heads at our disposal we have been unable so far to repeat these experiments. Mr. Hubbard made an infusion by pouring hot, not boiling water upon the powder, but found it ineffective and quite worthless, and we have had similar results with the decoction of the powder.

The wet application of Pyrethrum, in whatever form it may finally prove most convenient, is unquestionably superior to its application in powder form, the former being by far more economical and, with the improved appliances, enabling us the better to reach all the worms.

EFFECT OF PYRETHRUM UPON OTHER INSECTS.—While arsenical poisons directly[53] affect only those insects which feed on the leaves of the cotton plant, or, in other words, only the enemies of the plant, Pyrethrum affects all insects that happen to be on the plants at the time of the application. Since among these are great numbers of some of the most efficient enemies of the worm, it is not without interest to record here such observations as have been made incidentally in regard to the effect of Pyrethrum on other insects besides Aletia, even if they include some that have no connection with the cotton plant. Mr. Hubbard reports as follows:

Tried upon different insects, pyrethrum appears to affect the higher *Hymenoptera* more than other insects. Ants are almost instantly affected. Wasps continue feeding for about 20 seconds, and are violently affected in from 1 to 2 minutes. Larvæ of all kinds are more quickly affected than imagos. Termites, owing probably to their tender bodies, are instantly affected and soon killed. Spiders resist longer than anything else. They sometimes change their skins when dusted with the powder. *Copris* and *Phanæus* are slightly affected and long resist the action of the powder. *Scolopendridæ* affected similarly to spiders. Bugs slightly affected, especially the large and heavily armed predaceous species. Roaches very violently affected. These observations refer to the immediate action of the dry and undiluted powder, and are comparative only.

Mr. Schwarz records the following observations on this point:

A thorough application of my alcoholic extract (10 drams to 2 gallons of water), and of my pyrethrum-water (200 grains of powder to 2 gallons of water), affected other insects as follows: They had no visible effect on all spiders, without exception, on the larvæ of *Lagoa* sp., *Hyperchiria io*, *Acronycta oblinita*, and *Ecpantheria scribonia*; they affected, but not fatally, the common Black Cricket, the various species of grasshoppers and their larvæ, the ground-beetles so common under the fallen leaves at the base of the plants (*Anisodactylus rusticus*, *Platynus punctiformis* and *P. maculicollis*),

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various Ladybirds, and large Chrysomelidæ. Fatally affected were all Hymenopterous insects, all Heteroptera and Homoptera (no opportunity, however, to try on Aphids); several species of naked Noctuid larvæ, *Callida decora*, *Coptocycla aurichalcea* and its larvæ, *Monocrepidius livïdus* and *M. vespertinus*, Ladybird larvæ, larvæ of *Chrysopa*, *Hemerobius* and *Syrphus*. Of all these insects the ants are by far most readily affected. The mixtures hardly affected *Pieris* larvæ, and not at all those of *Terias nicippe*.

It cannot be denied that this promiscuous destruction of friend and foe alike is a disadvantage, but all observers agree that the Cotton Worm is one of the first insects to succumb to the effects of the powder.

When, in 1879, we began to experiment with Pyrethrum in the field, there was little hope of successfully applying this expensive material on a large scale, but we have seen that even at the high price of 75 cents per pound the powder can be successfully used in the field at a cost not exceeding that of the dry Paris green method, and against an insect which is remarkably well protected by its habits and by the large size of the plants upon which it depredates. That the price of Pyrethrum can and will be considerably lowered admits of no doubt. Mr. Milco, of Stockton, Cal., wrote us in 1879 that the cost of production, milling, &c., on a large scale need not exceed 6 to 7 cents per pound. The seed of *Pyrethrum roseum* and *P. cinerariæfolium* was, in 1880, distributed by the U. S. Entomological Commission, while another supply of seed was sent out in 1881 and 1882 to parties all over the country by the Department of Agriculture, accompanied by a circular containing all available information regarding the cultivation and use of the plant. Though many failures have been reported, the plants have grown well in other cases, and it can hardly be doubted that the cultivation of pyrethrum will prove a success in many portions of the Eastern States, and that the market price of the powder will be lowered in a future not very far remote. That the farmer or planter is able to raise his own supply of powder is an important point not only in regard to cheapness of the material, but also as a protection against adulteration, which is the more dangerous in this case as the adulterated article cannot be distinguished from the genuine one except by continued experimentation.

EXPERIMENTS WITH THE POWDER FROM OX-EYE DAISY.

In the summer of 1880 Mr. William Saunders, of the Department of Agriculture, called our attention to the possibility of discovering in one of our most common plants, the well known Ox-eye daisy, insecticide properties similar to those possessed by Pyrethrum. He wrote us as follows: "On running over the pages of your Bulletin on the Cotton Worm I notice that you have something to say about pyrethrum powder, which reminds me that Dalmatian Insect Powder is, according to some authorities, made from the *Leucanthemum vulgare*, our Ox-eye daisy. In Europe it is called *Chrysanthemum leucanthemum*. Could we not so utilize that vile weed? I think the subject is worthy of experiment." When perfectly dry these were finely ground, and we obtained

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a powder so alike in color and smell to Pyrethrum powder that the two could not readily be distinguished. But however great this external resemblance, the two differed widely in efficacy as insecticides. Dr. Barnard, who, while still in Ithaca, New York, made some preliminary trials with the alcoholic extract from the fresh or half dried flower heads, wrote:

"I have no evidence that the extract will prove of any practical value, after having atomized it on to many specimens of larval potato-beetles, aphides, young grasshoppers, *Mamestra picta*, *Pieris rapæ*, and other caterpillars."

As to the experiments with the dry powder, Mr. Schwarz reports as follows: "Ox-eye daisy powder was repeatedly applied to Cotton Worms in the earlier part of October in the following forms: 1st, as dry powder, mixed with flour, and undiluted; 2d, stirred up in water; 3d, as alcoholic extract (made by repercolation) diluted with water and undiluted; 4th, as tea; 5th, as a fume. In no instance even the slightest effect on young or old worms was observed, though powder and fluids were applied in large quantities and undiluted. The experiments were all conducted with a view to ascertain the effect of the powder on the worms by actual contact, and not by acting through the stomach. I am also not prepared to say whether or not this powder has any effect on other insects; but there can be no doubt that if applied like pyrethrum, it is utterly worthless as a remedy for the Cotton Worm."

Other experiments with infusions and decoctions made from the fresh and dried flower heads and other parts of the plant, gave no better results, and every hope of obtaining in this plant a substitute for pyrethrum had to be abandoned.

EXTRACTS AND DECOCTIONS FROM VARIOUS PLANTS.

That there are plants which contain volatile oils similar in effect to that possessed by Pyrethrum, admits of little doubt. Professor Barnard extracted from Bitter Almonds an oil which, upon experimentation, proved to be equal or even superior to pyrethrum powder. However, this oil is so expensive that no further experiments were made with it. The vapor exhaled from the husk of certain South American nuts is so strong as to be dangerous even to man, but we were not able to procure such to ascertain their effect upon insect life. The method practiced by European entomologists of killing microlepidoptera and other delicate insects by the vapor emitted by laurel leaves also deserves mention here.

But few of our insecticides are, so far, drawn from the vegetable kingdom, the most important of them being tobacco, hellebore, and pyrethrum; but there is a wide field in this direction for investigation. The task of discovering among the multitude of plants such as may possess insecticide properties is a difficult one, since we have little to

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guide us. Plants that are poisonous to man and the higher animals are usually harmless to insects; others may possess insecticide qualities only at a certain season or only when they are dried or otherwise prepared; in still other plants only one part, *e. g.*, the flower or the root, may prove useful, perhaps only at a certain stage of development, and the rest worthless. Hence experiment in this direction must be more or less tentative, and practical results will follow only, if at all, the most extensive trials. Other difficulties also present themselves. Two observers, while experimenting with the same material, with the same instruments, and under precisely similar conditions, often report varying results; or the same observer after a favorable result in the first trial obtains a quite different result in subsequent trials. In the case of the Cotton Worm, with its rapid development, there is, also, great risk of drawing false conclusions, the most frequent cause being the apparent sudden disappearance of the worms, or at least of a large portion of them, after the application of the "remedy." The worms may have simply changed to chrysalides or may have been carried away by enemies. Again, the presence of a number of dead worms upon and under the plants is often misleading, as such worms may have been killed by their numerous enemies. Finally, very young worms, or such as are just in the act of molting, are often killed by the mere force of a spray thrown upon them, while others that have fallen to the ground, and are more or less covered with soil, exhaust themselves in their frantic efforts to get rid of the incumbrance.

In this connection, also, it must be remembered that experiments made indoors are without practical value unless confirmed by repeated experiments in the field.

The plants with which we have experimented are partly such as were recommended by correspondents as being efficient for the Cotton Worm or other insects;* partly such as from their immunity from insect attacks might be presumed to possess insecticide properties. Prevalence and cheapness being desiderata in any plant that might prove to have destructive qualities, many of the weeds that by their abundance, persistency, and power of adaptation are so obnoxious to agriculture in the South were tested. In order to test such plants thoroughly they should be used both fresh and dry, and in flower, fruit, leaf, and root. This is a work of considerable magnitude which cannot possibly be accomplished in one or two seasons, and for the purpose of this investigation we deemed it advisable, with few exceptions, to first try alcoholic extracts and decoctions, mostly made from the fresh plants, leaving for the future more complete experiments with such as give promise of success. While the results thus far obtained seem discouraging, considering the outlay in money and time, and while in no case was the effect upon the worms such as would warrant the recommendation of any of these plants for

* A few of these plants could not be recognized from the popular name given by the correspondent, and could, therefore, not be tested.

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the purpose intended, yet we are not without hope that some of them will ultimately prove valuable additions to the list of insecticides from the vegetable kingdom.

No uniformity in preparing the extracts and decoctions was required from the agents of the Commission, as we deemed it best to have them prepared in different ways and in various proportions. This may explain, in some measure, the discrepancy in the results obtained.

Mr. James Roane prepared during his stay at Selma a large number of extracts, decoctions, and infusions, reporting as follows in regard to their preparation: "My infusions and decoctions are made in various degrees of concentration, while the alcoholic extracts (prepared by macerating the crude drugs in one part of pure alcohol and one part water for fifty hours and then subjecting them to a strong pressure in a screw press) have been made of uniform strength—of the green leaves four ounces being taken to the pint; of the dried, two ounces. In all of my preparations I have used the leaves and herbal parts of the plant, excepting the bark of the root of sassafras and the berries of the China tree. The decoctions and infusions have been made in quantities ranging from two quarts to a gallon and the alcoholic extract invariably a pint."

These preparations, amounting in all to forty-eight, were tested at Selma, Ala., during the months of July, August, and September, by Mr. Schwarz.

Professor Jones prepared at Oxford a smaller number of vegetable extracts and decoctions, mostly from the same species of plants used by Mr. Roane, the preparations being made in various degrees of strength, the plants or parts of the plant being first carefully dried in the shade. He tested them himself at Oxford on the Cotton Worm as well as on other injurious insects, and sent also a supply for experimentation to Selma, Ala. Professor Jones's decoctions were made in large quantities, so that they could be used on an extensive scale.

Similar experiments were conducted by Dr. Barnard, at Ithaca, N. Y., with a small series of extracts prepared by him. As he had no Cotton Worms at hand he tested his preparations on various other insects, but he forwarded samples to Selma, Ala., where they were also tested on the Cotton Worm.

Finally, Professor Stelle briefly gives in his report the results of a few experiments with vegetable preparations made during his stay in Texas, while a few other experiments made by Mr. Schwarz, in 1879, have already been recorded in the first edition of this work.

The effects of these substances on the Cotton Worm may be threefold first, they may kill it by contact; secondly, they may, like the mineral poisons, act through the stomach; thirdly, they may render the leaves of the plant so distasteful to the worms as to drive these from the plant. Effect upon contact is easily observable even where not fatal. It usually takes place very soon after application, and it may safely be

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assumed that if there is no effect observable about one hour after application, the substance is innocuous. A general disturbance of the worms immediately follows the application of any substance, however harmless, and should not be taken in account. Effect through the stomach is not visible until after at least twenty-four hours, and in some instances not until the second or even the third day after application, as the worms (prompted no doubt by instinct) do not feed upon a substance injurious to them until they get hungry. As to the third point, almost any strange substance thrown or sprayed on the leaves stops the worms from eating for a shorter or longer period, and observations as to the final result must, therefore, be extended over several days. A fourth point, viz., the possible influence of such applications on the oviposition of the moth has already been referred to.

The following list of plants experimented with is given without any systematic arrangement. If no effect on the worms was obtained by several independent experimenters, we have simply added "no result." Otherwise the results obtained by the individual observers are given in condensed form, with the name of the observer added in brackets.

AILANTHUS TREE ("Tree of heaven," *Ailanthus glandulosa*). Decoction and infusion of leaves. No result.[54]

JAMESTOWN WEED (*Datura stramonium*). Alcoholic extract from dried and ground seed. No result. [R. W. Jones.] Alcoholic extract and decoction from leaves. No result. [E. A. Schwarz.]

BONESET (*Eupatorium perfoliatum*). "Powdered leaves applied to the plant seemed obnoxious to the worms." [J. P. Stelle.] Infusion from leaves. No success. [E. A. Schwarz.]

DOG FENNEL (*Helenium tenuifolium* and *autumnale*). "This plant, of which I entertained considerable hopes, will render the cotton plant so obnoxious that the worms won't feed upon it, but it won't kill the worms." [J. P. Stelle.] Decoction, infusion, and alcoholic extract. No result. [R. W. Jones and E. A. Schwarz.] Flower heads dried and powdered. No result. [E. A. Schwarz.][55]

COCKLEBUR (*Xanthium strumarium*). Alcoholic extract and decoction. No result. [E. A. Schwarz.]

BUCKEYE (*Æsculus glabra*). Alcoholic extract from fruits. No result. [R. W. Jones.] Alcoholic extract and decoction of leaves. No result. [E. A. Schwarz.]

RAG WEED (*Ambrosia trifida*). Decoction, infusion, and alcoholic extract. No result.

HOG WEED (*Ambrosia artemisiæfolia*). Alcoholic extract and decoction. No result. [E. A. Schwarz.]

INDIGO WEED (*Baptisia tinctoria*). Alcoholic extract and decoction. No result. [E. A. Schwarz.]

DEADLY NIGHTSHADE (*Atropa belladonna*). Decoction and alcoholic extract of leaves. No result. [E. A. Schwarz.]

TOBACCO (*Nicotiana tabacum*). "Strong decoction of dry leaves freely

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applied affects and kills by contact very young worms, but has little or no effect upon the average sized and full-grown ones. They do not feed, however, for a considerable length of time, changing their places in search of fresh leaves." [E. A. Schwarz.]

PRICKLY ASH (*Zanthoxylum carolinianum*). Powdered leaves. "Seemed obnoxious to the worms." [J. P. Stelle.]

SMARTWEED (*Polygonum hydropiper*). Decoction of leaves and alcoholic extract. No result.

MULLEIN (*Verbascum thapsus*). Alcoholic extract and decoction of leaves. No result. [E. A. Schwarz.]

PENNYROYAL (*Hedeoma pulegioides*). Alcoholic extract, decoction, and infusion. No result. [R. W. Jones.]

HORSEMINT (*Monarda punctata*). Alcoholic extract of leaves. No result. [E. A. Schwarz.]

HOREHOUND (*Marrubium vulgare*). "This decoction emits a very powerful and disagreeable stench, which I could still smell on the cotton-plants two days after application, but it had no effect whatever on the worms, nor did it prevent the moths from ovipositing. The alcoholic extract did not possess this unpleasant smell, and had likewise no effect whatever." [E. A. Schwarz.]

CHINA TREE (*Melia azedarach*). "I sprayed a decoction of leaves and small twigs on the cotton plants, and I think it had a large effect in preventing the moths of Heliothis and Aletia from ovipositing, but it did not destroy the larvæ. The alcoholic extract of the berries and leaves adulterated with twice its quantity of water was sprayed on twelve Aletia larvæ, full-grown; most of them fell to the ground, and four died. This experiment was repeated with about the same result; but when the extract was diluted with ten parts of water it failed to bring the worms to the ground." [R. W. Jones.] "This plant, in the form of alcoholic extracts as well as decoctions, undoubtedly possesses some insecticide properties, acting upon the worms by contact, but in a manner quite different from pyrethrum and kerosene. The acting principle seems to be of a narcotic nature, the worms not showing any unusual disturbance after application. They seem to get benumbed, and, gradually losing their strength, finally loosen their hold and drop to the ground, where they lie without falling in convulsions. The more full-grown worms are, however, but little affected, and of the smaller ones a large proportion recover. This is the most promising plant of the whole number I experimented with, though the extracts and decoctions as applied by myself are altogether too weak to be used as a remedy for the worms. The preparations made from the berries are evidently more effective than those from the leaves, and the extracts and decoctions made by Mr. Roane proved to be more effective than those I received from Prof. R. W. Jones, of Oxford. For further experiments I would recommend preparations from the *dried* green berries." [E. A. Schwarz.]

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IRON WEED (*Vernonia noveboracensis*). Alcoholic extract and decoction. No result. [E. A. Schwarz.]

TANSY (*Tanacetum vulgare*). Alcoholic extract and infusion. No result.

DOCK WEED (*Rumex* sp.). Alcoholic extract. No result. [E. A. Schwarz.]

SPEARMINT (*Mentha viridis*). Alcoholic extract. No result. [E. A. Schwarz.]

JERUSALEM WEED (*Chenopodium anthelminticum*). Alcoholic extract and infusion. "This is another exceedingly strong-smelling substance, especially in the form of alcoholic extract made from the blossoms and green fruits, but no effect whatever was observed." [E. A. Schwarz.]

SASSAFRAS (*Sassafras officinale*). Alcoholic extract from the dried bark of the root. No result. [E. A. Schwarz.]

GOAT WEED (*Croton texanum*, *C. glandulosum*, *C. capitatum*, and *C. monanthogynum*). Decoction from leaves and blossoms. Also a very strong-smelling fluid. No result. [E. A. Schwarz.]

BLACK WALNUT (*Juglans nigra*). Alcoholic extract and decoction. "A substance which, especially in the form of decoction, deserves further attention. It has no effect on the worms upon contact, but renders the leaves decidedly distasteful to them. On the second day after application the leaves which had received a large amount of the decoction remained fully intact, the worms having removed to the lower branches and to those portions of the plants which were not, or but little, treated with the decoction. Several worms kept in captivity without food except leaves drenched with this decoction finally fed upon them and successfully changed to pupæ. The decoction stains the leaves dark brown, but apparently without injuring them." [E. A. Schwarz.]

HORSE NETTLE (*Solanum carolinense* and *S. cornutum*). Decoction. No result.

INDIAN HELIOTROPE (*Heliophytum indicum*). Decoction. No result. [E. A. Schwarz.]

MOCK ORANGE (*Philadelphus inodorus*?). This is recommended as an insecticide all over the South, for the only reason, it seems, that it is injurious to stock. Decoction, infusion, and alcoholic extract had no effect whatever on the worms.

WHITE-BORDERED EUPHORBIA (*Euphorbia marginata*). Decoction. No result. [E. A. Schwarz.]

COFFEE WEED (*Cassia occidentalis*). Alcoholic extract and decoction. "This has undoubtedly some effect on the worms, though much less than the China tree berries. Appears to act upon contact, though very slowly. The worms appear to get affected several hours after application, resting motionless and without feeding, but were recovered on the second day. Some young worms were found dead one day after application, but it is doubtful whether from the effect of the decoction or killed by the force of the spray." [E. A. Schwarz.]

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POKEWEED (*Phytolacca decandra*). Decoction of leaves and berries; also alcoholic extract from the dried root. No result. [R. W. Jones.]

"I did not obtain any effect with the decoction prepared by Messrs. Jones and Roane, but a very small quantity prepared by Professor Barnard had a decided effect, killing the young worms and seriously affecting the older ones. It was applied undiluted, by means of a hand atomizer. The extract acted upon contact in a very short time, the young worms falling in convulsion of short duration before dying. The old worms had all recovered the second day. Professor Barnard afterwards told me that this extract was a very strong one." [E. A. Schwarz.]

MANDRAKE (*Podophyllum peltatum*). Powder from dried root dusted on the worms; also applied stirred up in water. No result. [E. A. Schwarz.]

QUASSIA TEA (2 ounces to one-half gallon of water). "Worms feeble next morning, but alive." [C. V. Riley.]

CAPSICUM.—Mr. Schwarz experimented with this substance, and reports as follows:

September 18.—Undiluted capsicum was sprayed (with the hand atomizer) indoors on some cotton worms of average size. No immediate effect visible and none one hour afterwards, but twelve hours later all worms were dead.

September 19.—The same experiment repeated in the field on worms on an isolated plant. No effect visible after two hours, but six hours later all worms sprayed with the substance were found dead. Applied capsicum diluted with five times the amount of water. No effect visible after twelve hours, the worms feeding again on the leaves sprayed with the mixture. The experiments were then discontinued on account of the most unpleasant effect of the capsicum upon myself. From my last experiment, however, I do not believe that capsicum will bear much dilution without losing its efficacy on the worms. It undoubtedly affects the worms by contact, though I am unable to explain the exact manner in which it acts.

None of these vegetable preparations appear to be hurtful to the plants, though in several instances it has been observed that the leaves became slightly scorched upon application during very hot, bright sunshine, especially in forenoon after the dew had disappeared. As the same substances were subsequently or previously applied without injury to the plants, there can hardly be any doubt that this injurious influence must be attributed to other conditions. While speaking of arsenical poisons and kerosene, I mentioned that they are more liable to injure the plants when applied during hot sunshine than during cloudy weather or toward evening. In the case of these vegetable preparations the same conditions doubtless prevail.

As a remarkable fact in connection with these experiments, we would still mention the slight effect produced on the worms by alcohol. Many of the alcoholic extracts experimented with consisted of one-third alcohol, and had no effect whatever, even upon very young worms. Even pure alcohol, when sprayed on the worms, only kills the youngest ones, the average-sized ones soon recovering, while the full-grown ones are hardly affected.

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YEAST FERMENT: FUNGUS INFECTION.

The fact that insects, like other animals, are subject to diseases of an epidemic nature and of a fungus origin has led some persons to hope and believe that the germs of destruction could be, so to speak, artificially sown among those which it was desired to destroy. Dr. J. L. LeConte, of Philadelphia, was the first in this country, so far as we are aware, to suggest the introduction and communication of such diseases at pleasure for the destruction of insect pests, in a paper read at the Portland (1874) meeting of the Association for the Advancement of Science. Dr. H. A. Hagen, of Cambridge, Mass., has elaborated the idea, and strongly recommended as a general insecticide the use of beer-mash, or diluted yeast, applied with a syringe or a sprinkler. We quote the following somewhat sanguine words from an article which he published in *Canadian Entomologist* (vol. xi, June, 1879):

Dr. Bail asserts that he has proved by many skillful experiments that four species of microscopical fungi are merely different developments of the same species. One of them, the fungus of the common house-fly, is the vexation of every housekeeper. The dead flies stick in the fall firmly to the windows, or anywhere else, and are covered by a white mold not easy to be removed. The second is the common mold, known to everybody, and easily to be produced on vegetable matter in a damp place. The third is the yeast fungus, a microscopical species, and the basis of the work done by yeast of fermentation. The fourth is a small water-plant, known only to professional botanists. Dr. Bail contends that the spores of the fungus of the house-fly develop in water in this last species, out of water in mold, and that the seeds of mold are transformed in the mash-tub into yeast fungus.

The experiments made by Dr. Bail cover a period of more than a dozen years, since the numerous objections which were made against his results induced him to repeat again and again his experiments in different ways. I am obliged to state that even now prominent botanists do not accept Dr. Bail's views, which he maintains to be true and to be corroborated by new and sure experiments, This question, important as it may be for botanists, is without any influence regarding my proposition, as Dr. Bail has proved that mold sowed on mash produces fermentation and the formation of a yeast fungus, which kills insects as well as the fungus of the house-fly. I was present at the lectures of Dr. Bail before the association of naturalists, in 1861, which were illustrated by the exhibition of mold grown on mash on which the fungus of the house-fly had been sown, and by a keg of beer brewed from such mash, and by a cake baked with this yeast.

* * * * * * *

Dr. Bail has proved by numerous experiments that healthy insects brought in contact with mash and fed with it are directly infested by the spores of the fungus with fatal consequence. These facts, not belonging strictly to the main part of his experiments, were observed first by chance and later on purpose. The most different insects, flies, mosquitoes, caterpillars, showed all the same results. The experiments were made in such a delicate manner that a small drop of blood taken with an oculist's needle from the abdomen of a house-fly left the animal so far intact that the same operation could be repeated in two days again. Both drops examined with the microscope proved to be filled with spores of fungus.

* * * * * * *

Considering those facts, which are doubtless true, and considering the easy way in which the poisonous fungus can always and everywhere be procured and adhibited, I believe that I should be justified in proposing to make a trial of it against insect

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calamities. Nature uses always to attain its purposes the most simple and the most effectual ways; therefore it is always the safest way to follow nature.

Beer mash or diluted yeast should be applied either with a syringe or with a sprinkler; and the fact that infested insects poison others with which they come in contact will be a great help. Of course it will be impossible to destroy all insects, but a certain limit to calamities could be attained, and I think that is all that could reasonably be expected. In greenhouses the result would probably justify very well a trial, and on currant worms and potato bugs the experiment would not be a difficult one, as the larvæ of both insects live upon the leaves, which can easily be sprinkled. But it seems to me more important to make the trial with the Colorado grasshopper. I should recommend to infest the newly-hatched brood, which live always together in great numbers, and I should recommend also to bring the poison if possible in contact with the eggs in the egg-holes to arrive at the same results, which were so fatal to Mr. Trouvelot's silk raising. After all the remedy proposed is very cheap, is everywhere to be had or easily to be prepared, has the great advantage of not being obnoxious to man or domestic animals, and if successful would be really a benefit to mankind. Nevertheless I should not be astonished at all if the first trial with this remedy would not be very successful, even a failure. The quantity to be applied and the manner of the application can only be known by experiment, but I am sure that it will not be difficult to find out the right method. I myself have more confidence in the proposed remedy, since it is neither an hypothesis nor a guess-work, but simply the application of true and well-observed facts. I hear the question, When all this has been known for so long a time, why was it not used long ago? But is that not true for many not to say for all discoveries? Most of them are like the famous Columbus egg.

It will be seen that Dr. Hagen attaches little importance to the present opinion and judgment of mycologists as to the non-identity of the several fungi alluded to. We have corresponded with some of the leading cryptogamists of this country on this subject, and they are quite unanimous in the opinion that there is no one "of the least reputation," to use Professor Farlow's words, who admits that there is any connection between the fly fungus, known as *Empusa muscæ* but belonging to the genus *Saprolegnia*, and the yeast fungus, *Saccharomyces cerevisiæ*. It is to be regretted, also, that more precision has not been used by Dr. Hagen in referring to these fungi, for the "common mold known to everybody" is most vague, since many different species of mold are recognized by specialists, while "a small water-plant, known only to professional botanists," is such an indefinite expression as to inspire little confidence in the thoroughness of Dr. Bail's experiments. Leaving to the specialist, however, the question as to the kind of relation existing between the lower forms of fungi intended to be referred to by Dr. Hagen, we felt that the suggestion coming from so eminent an entomologist was well worthy of practical trial. We took occasion, therefore, to experiment with beer mash by spraying and sprinkling it upon various plants that were to be fed in our vivaria to Lepidopterous larvæ. The principal larvæ thus experimented with were of *Papilio asterias*, *Danais archippus*, and *Pieris rapæ*. The results gave no encouragement to the hope that anything practical would result from the proposed remedy. The larvæ fed with equal avidity and went through their transformations as well as the same species had done on

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repeated occasions without being treated to beer mash. An incident connected with these experiments which we made is, however, well worthy of being mentioned; because it shows how very easily single experiments may lead to false hopes and conclusions. A certain proportion of the last-named larvæ—the proportion differing in the different lots treated—perished before or while transforming to the chrysalis state. They became flaccid and discolored, and after death were little more than a bag of black putrescent liquid. We should have at once concluded that the yeast remedy was a success had we not experienced the very same kind of mortality in previous rearing of this larva, and had we not, upon returning to the field from which the larvæ in question were obtained, found a large proportion similarly dying there.

Though from this experience we had little faith in the value of the proposed remedy as against the Cotton Worm, we nevertheless took pains to have it tested in 1879 both by Professor Smith in Alabama and Professor Willet in Georgia, and in 1880 by Messrs. Bailey, Hubbard, Jones, Schwarz, and Stelle in various parts of the cotton belt. The experiments were made in each instance during the latter part of the season, when the vitality of the worms was already considerably lowered, a condition which, in our experience with fungus diseases in insects, was eminently favorable for satisfactory trial. But in spite of these favorable conditions the uniform result of all the experiments showed that there was no insecticide virtue in the ferment. For this reason we merely add it to the other substances just enumerated which proved to have no insecticide property.

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CHAPTER XI.

MACHINERY AND DEVICES FOR THE DESTRUCTION OF THE WORM.

By Prof. W. S. Barnard, Ph. D., *Assistant.*

I.—SPRAY NOZZLES.

Since most of the nozzles invented have been claimed independently of insect-destroying devices, yet are applicable for throwing poison, and any nozzles may be used on other machines than those they were first employed on, it has seemed to me advisable to treat them all in a separate chapter, and to consider them in what I have found to be four natural classes, viz: 1. Many-punctured nozzles; 2. Slot-nozzles; 3. Deflector nozzles; and, 4. Centrifugal nozzles. The nozzles which at present seem to be the best will be described under the last of these classes.

MANY-PUNCTURED NOZZLES.

[Plates XIV and XV.]

The nozzles of this class are constructed on the dissection principle, dividing the liquid into a group of small jets by forcing it through a many-punctured face.

The best nozzles of this group are such as have the tangential entrance. A removable face is of great importance; also, the perforations should be made and located, or directed, according to the principles explained below.

The old-fashioned sprinklers and sifters, with which all are familiar, whether made of perforated sheet metal or wire-gauze, have generally proved unpractical for administering insecticides, because of the fine holes becoming clogged by the poison and other materials. To prevent this, various stirring, shaking, and straining appliances have been combined with them, but without as good results as are to be desired.

The manner in which the holes are made often causes much trouble. These are sometimes so cleanly drilled or punched that little or no burr surrounds them; but usually they are so punched that on one side a high burr or ridge is formed around the puncture, while on the other side each hole appears in the bottom of a funnel-shaped pit, which, if on the inside, is excellently calculated to collect and hold particles over

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the hole to clog it. If a sharp center-punch be employed, the holes ought to be punched from the outer surface. In this manner, each hole, as approached upon the inner side, is upon an eminence where clogging materials find unstable equilibrium, and they cannot well lodge except between the holes. Though this may seem a small matter, very much trouble arises from its not being observed.

The spray should generally be made to spread rather broadly, and can get its divergent or radiating form from the convexity of the face from which it is discharged; but where the face is flat, as is sometimes advisable or necessary, especially where the face is made reversible, the divergence can be obtained by drilling a part or all of the holes in a somewhat radiating direction. Also, where the water is squirted with considerable force, a fine spray will be obtained, and with ample spread, by boring the holes straight through a concave face, or else in such a direction through any thick face that sets of two or more jets converge to a *focus*, and there collide to dissipate each other into a finely atomized condition. Using this principle, a well-dispersed spray of better volume and quality can be produced from a smaller number of holes of larger capacity, whereby they are less liable to choke. On this plan the best many-punctured force-pump nozzles of the future will probably be made.

The rose sprinkler-heads of watering pots and nozzles are commonly provided with no openings except the narrow neck by which they join upon the spout, and this does not admit the removal of foreign matters which collect inside. The head should be made of easily separable parts, to allow the interior face of the perforated side to be cleaned, as will be seen in the patterns, some of which have the punctured face reversible. Squirting through the perforations in an opposite direction cleans them without injury, while punching through them with any hard instrument is a slower process and sure to damage.

It is advisable to strain the water before it is admitted to nozzles, of whatever kind, by some of the devices shown in combination with the various reservoirs for carrying it and pumps for forcing it, as described later in this report. There is always an advantage in strainers, although they add to the machine an increased number of holes to be clogged, for, if fine enough, they soon clog; yet it may be used for a longer time without stopping, and the damage to the fine perforations of the face by punching dirt out of them should be avoided. The strainer should be large, and does not have to be cleaned so often as would the nozzle proper; still, where the gauze surface is exceedingly fine, or where the fluid squirted is much laden with solid particles, the strainer may clog very quickly.

EDDY-ROSES.—All the many-punctured heads may be improved upon by introducing the liquid in an eccentric manner, and parallel to a tangent to the circumference, to cause it to whirl inside, and thereby make less liability to clogging by keeping active any internal rubbish which

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would tend to dam up the small outlets. Such material, if kept in motion, does not impair the spray. Some of the examples showing this principle in many-punctured nozzles, as discovered and applied by myself, are represented in Plate XIV, Figs. 1, 2, 3, and 4.

In Plate XIV, Fig. 1, *c* and *c* indicate two can-screw caps, *s* the perforated circumference, and *a* the spout which enters the chamber at a tangent at *x*.

A section showing the interior of a similar nozzle, which has but one can-screw opening, appears in Fig. 2, in which *a* designates the eccentric spout, and *i* a rotary brush inside of the rotation chamber, where it is made to whirl by and with the water to wipe away clogging materials from the perforated periphery. Differently formed brushes or other bodies may be inserted on an axis or free, and one or more small, loose projectiles can be placed inside for the same purposes.

When nozzles of this form are used on watering pots it is generally preferable to have the perforations on the outer rim, as shown, in order to throw a flat fan-shaped spray; but a head may be made as in Plate XIV, Figs. 3 and 4, with a punctured face toward one side as a convenient form for spraying sidewise in a broadcast manner or vertically down or upwards.

A sprinkler made on this plan, but with a flat cap-plate or an inserted plug instead of the projecting screw-cap described, and with divergent or colliding jets, is the best many-punctured nozzle for dragging or carrying beneath plants to squirt an upward spray; but better sprays for this purpose are made by nozzles of class 4.

PLUG-ROSES.—These are certain nozzles which emit the spray through grooves cut in the surface of a plug or its surrounding wall.

A rather curious nozzle of this class was used in the machine patented in 1873 (Nos. 145571, and 145572) by Mr. Jehu W. Johnson, of Columbus, Tex.; and is illustrated in Plate XV, Fig. 4.

A plug with parallel grooves as water passages along its outer surface, and fitted into a cup-like expanded end of a tube, is held in place and may be set out or in, to increase or diminish the spray, by an adjustable thumb-screw. The resultant spray is bell-shaped.

Mr. J. C. Melcher, of Black Jack Springs, Texas, is making a nozzle in which a metallic grooved plug is used. The plug is a very flat cone, and its rim projects beyond the jet pipe enough to spread the spray quite wide. Inside of the pipe the apex of the cone has a projecting eye, through which a string is drawn with its ends passed out through the sides of the tube at points farther back, where the two ends are tied together to hold the cone in place.

A somewhat similar irrigating nozzle containing a grooved plug for dividing water into a spray was patented in 1878 (No. 205733) by Mr. Samuel Dawson, of Hempstead, N. Y., and a more spirally-grooved plug for the same purpose and for giving a rotary motion to the spray was patented in 1879 (No. 220277) by Mr. F. N. Foster, of Buffalo, N. Y.

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Another modification of the same principle appears in a nozzle claimed in an insecticide machine in patent No. 260761, July 11, 1882, by Mr. G. G. Lynch, of Illawara, La. The sprays from all these plug-roses are comparatively coarse and cannot be well adapted to poisoning on under-surfaces, while the pores are very liable to become stopped.

COLLIDING JETS.—The nozzle resembling a gas-jet (in Plate XV, Fig. 5), having two converging outlets by which the two streams emitted meet, as shown by the arrows, to form a fish-tailed spray, has been used. When great pressure is applied to the water forced through it, as by a force-pump or by Mr. Daughtrey's air-pump machine (Plate XXXVI), the two streams meet with such great dispersing force as to dash each other into a fine spray. The arrangement of the outlets at the closed end of a tube and their smallness in size and number as used in machines heretofore, and as they must be to give small enough sprays for single rows in poisoning from beneath, subject them to clogging to an extent unpractical for this purpose. The stoppage of either hole destroys all the spraying power. For very large sprays in broadcast sprinkling the size of the outlets may be increased to a practical extent, and a number of such converging and interrupting streamlets may be produced from holes in the same plane or from the surface of a pipe or the face of a nozzle which is concave or funnel-shaped. In rose-heads, with or without reversible faces, the holes can be cut in pairs of twos or in threes, such that their jets will collide, and a row of such pairs can be used on the side of a trailing pipe.

For spraying upwards I have produced the twin jets from the side of a tube, near its end, and from a terminal chamber. The tube should open by a cap or plug for cleaning out, and in its best shape has a terminal recurrent or rotation chamber or passage as described elsewhere.

A nozzle-end essentially the same as the perforated one used in gas-jets and combined in Mr. Daughtrey's machine, but without the internal cone, n^2, which is more likely to assist clogging than prevent it, was patented in 1878 (No. 202207) as an attachment upon the ends of hose-nozzles, by Mr. Adolph Weber, of Detroit, Mich. A nose-piece having this kind of discharge and also a parallel main bore for a solid jet, but combined with the end of a hose-pipe by a slide-plate base, so that either kind of jet may be adjustably set in use instead of the other, was secured to Mr. A. B. Prouty, of Worcester, Mass., in patent No. 225721, March 23, 1880.

On account of the holes being larger and fewer, with the dispersion principle to produce fineness, these are certainly among the best nozzles of this class.

T-ROSES.—Broad sprays have been produced through tubular T-shaped, many-punctured nozzles. This principle is used in the ordinary street-sprinklers, but similar long perforated cross-pipes have been hauled above the cotton plants for sprinkling them. A good illustration of this is seen in the "Yeager Cotton Sprinkler" (Plate LIV, Fig. 7).

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In such nozzles it is economy to pierce only those sections of the cross-tube that come over the rows, and leave blank spaces with no spray between, as in the figure just referred to. Any perforated tube of this character should have its ends closed by screw-caps or plugs. The pipe can then be easily cleaned by opening these and passing through a long handle bearing one of the cylindrical brushes used for cleaning lamp-chimneys. Small hand-nozzles of essentially the same form have been made. One used by Mr. Warner on his "Saddle-sprinkler," described further on, has the cross-tube curved as in Plate XIV, Fig. 6, to throw the spray broader, and needs the improvements just suggested.

DIVIDED ROSE-HEADS.—A rose-head that separates from its neck, or from a solid jet-nozzle, by a clutch-coupling, which is the simplest way of joining and detaching these parts quickly, is sold by Messrs. Mast, Foos & Co., of Springfield, Ohio. It also leaves the interior somewhat accessible for taking out materials which choke it.

Mr. William Westlake, of Chicago, Ill., patented in 1871 (No. 174221) the use of the common sheet-metal can-screw as a large separable neck for rose-heads. In this way can be made a very cheap sheet-metal rose, as on Plate XIV, Fig. 7, with a wide hole through which to remove clogging materials from the interior.

But a still larger sheet-metal screw-coupling, separating the perforated face immediately from the body of the rose, as at *d*, in Plate XV, Fig. 2, was secured to Mr. L. B. Foss, of Boston, Mass., in 1876 (No. 174221). The preceding rose-heads are of cheap construction, and the last-mentioned one is the best of the very cheap ones heretofore made entirely of thin sheet-metal.

Mr. S. H. Fox, of Saint Louis, Mo., patented in 1880 (No. 223332) a strainer-nozzle, a plan-view of which is shown in Plate XIV, Fig. 8. It consists of two concentric cylinders. The inner one is of fine wire gauze. Through this the water entering by the inlet, *a*, must pass to the outer cylinder before reaching the very finely perforated sprinkler-face which emits the spray, *s*. This face is a screw-cap removable for cleaning. Also the gauze cylinder may be renovated by taking off a similar cap which bears the inlet-tube. This produces an uncommonly finely-divided spray for a nozzle of its class.

Yet the idea of removing the perforated rose-face from its body by a *cut* screw-juncture and screwing it on reversed, existed much earlier, and was embodied in a patent in 1869 (No. 87321) by Mr. James Barrows, of Hyde Park, Mass.

Another good rose with the face reversible was obtained in 1875 (Patent No. 116164), by Mr. W. T. Vose, of Newtonville, Mass. A plan-section of this is shown in Plate XV, Fig. 3, where *a* represents the neck to be connected with a spout or solid-jet nozzle and *c* is a screw-band which clamps the reversible circular face, *b*, to the walls of the chamber or rose-head, *a*. Being constructed of brass, nicely finished, it is probably the most durable and serviceable rose-head made. A number of differ-

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ent sizes are offered, and there is a series of face-plates substitutive for each other, but differing in the sizes and number of perforations.

PERIPHERAL-ROSES [DIVIDED].—Mr. J. C. Melcher, of Black Jack Springs, Tex., devised a discoid sprinkler-head with a many-punctured circumference, patented in 1876 (No. 172467). This is now made with a lid clamped fast by a screw and removable for cleaning out the interior.

To Mr. George Yeager, of Flatonia, Tex., was granted in 1879 (No. 219337) what he regards as an improvement in nozzles of this style, which consists in closing the top and base with sheet-metal screw-caps, detachable for taking out accumulations from within, while the cap held lowest serves to store the heavy sediments.

A nozzle, Plate XV, Fig. 6, producing this form of spray, is used on the Ruhmann sprinkler, but the arrangement for cleaning the interior is different, as may be seen in a sectional view, Plate XV, Fig. 7. By turning the T-shaped thumb-handle above, a small brush inside is made to sweep the inner surface of the punctured rim. It will be seen that such sweeping may be kept up constantly by an automatic process to be described in chapter XIII. For others see p. 193 and Pl. XIV, Figs. 1 and 2.

ROSE-COMBINATIONS.—There are many attempts to combine the rose-head and solid-jet pipe in one nozzle. This is done satisfactorily by having the rose separable from the pipe by a clutch, or screw-coupling, a plan which has been already spoken of, but which is illustrated in longitudinal section in Plate XV, Fig. 1 representing a nozzle patented in 1874 (No. 150742) by Messrs. W. Barry and L. H. Prentice, of Chicago, Ill. The circle shows the plug-cock perforated by the cavity of the solid-jet pipe that terminates inside of the rose-head *b*, which can be separated and screwed upon the nib *d*, for carrying it while a solid jet is used. Compare the clutch-rose, p. 195.

Several other devices for combining the rose and solid-jet in one nozzle have been found, but they are usually either a little too complex or costly to become popular, or else the construction is such as to impair either the spray or the solid-jet, or both.

SLOT-NOZZLES.

[Plates XVI, XVII, and XVIII.]

In slot-nozzles the form of the spray is given by a slot or group of slots from which it is emitted. The fluid forced from a slot expands in a somewhat fan-like shape, and then breaks up into a sheet of spray.

The best of these are such as have a slightly divergent discharge from the side of an eddy-chamber, with or without a deflector lip. The examples shown on Plate XVI, Figs. 4 and 5, now seem to be the most valuable, though, for broadcast work, such kinds as are shown in Figs. 1, 2, and 3 may sometimes be selected.

To lessen the clogging of small jets adapted to poisoning from beneath, only a single slot can be safely used, its lips should be far apart,

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and any reduction of the discharge capacity should be made by shortening the lips rather than by narrowing their interspace or slot. Diminishing by this rule the smallest slot attainable becomes only as long as it is wide, and loses the slot character.

If coarse slots do not make the spray fine enough, the latter may be thinned by adding a very short deflector lip, for it will be seen further on that the principles of deflection and rotation may be advantageously superadded upon or combined with the slot in almost all cases.

If the many-punctured principle is the worst for small jets, the slot principle cannot rank much better for this purpose. We have seen that to get a spray of very limited size the slot must be made either so narrow as to clog too much or must be shortened until it is about as long as wide, or the spray is not thrown thin and broad enough without adding a deflector. This suggests the substitution of the deflector in place of the slot. The round-hole deflector certainly ranks higher than the slot-nozzle for small jets, but it in turn is superseded for this purpose by the eddy-jets, as we shall see further on.

The slot answers for heavy broadcast sprinkling; but also in this work, if it has aperture enough not to clog, the spray will be too coarse for administering poison homogeneously, and if narrow enough to give sufficient fineness it will choke too much. Yet by certain improvements these defects may to some extent be remedied. The slots may be cut in various combinations, and several slotted rose-heads have been patented. A number of straight slots may be arranged as parallels, or as whorls of radials, or diagonals; also, curved slots may be grouped concentrically, or as whorls of radials, or diagonal curves or spirals. The only object in multiplying the number of slots in one and the same nozzle is to increase the volume to make large sprays without diminishing the quality by making a smaller number of slots coarser; for the finer the slot the finer the spray and the less its volume. Where force is applied groups of slots are preferable to the groups of smaller perforations of the many-punctured nozzles of the preceding group, and when rotation of the liquid is introduced in many-slotted chambers the cuts should be preferably concentric and thus parallel with the rotary current.

The slits may be cut on ends or sides of pipes, heads or nose-pieces of all forms, each end-form like each slot-pattern having its own peculiar adaptation; but the slotted surface should generally be in some way curved with cylindrical, conical, or spheroid contour to emit the spray in a radiating manner, and thus spread it more widely, or colliding slot-jets can be used. A rounded end should preferably have an internal cavity of capacity and form suited to adapt it for a rotation-chamber, since the rotary principle may also be introduced as an improvement in nozzles of this group.

Selecting with reference to these principles, and also for the purpose of adopting a nozzle-end of such form that it can be cut with slots of any form or grouping that may be made on either sides or ends, and

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especially with reference to the possibility of angular sprays for throwing vertically as well as direct ones for broadcast work, the general style of end shown in Plate XVI, Fig. 4, which is a rotation-chamber, *c*, with an eccentric entrance, *x*, seems preferable.

For broadcast throwing it will generally be most convenient to use a fan-shaped spray, projected straight ahead in the direction of the axis of the supply pipe. This is attainable by a slit cut as from *z* to *v* in Plate XVI, Fig. 3.

But for throwing sidewise or upward or downward at an angle with the spout axis and in the plane of rotation, shown by the arrow, a similar slot from *v* to *o* or from *z* to *s* should be used.

If such a side-spray is desired, but in a plane at an angle with the plane of rotation, the incision is made in the plane of the spray desired, and preferably between *s* and *z*, at or very near the entrance, where it will correspond to the hole of a whistle and be benefited by the increased spraying power at that point where the ingoing and outgoing streams conflict with each other.

The chamber should be capable of being opened to remove accumulations from within, as will be shown in several of the nozzles described further on in this section.

The lips of slit-nozzles ought to be cut slightly beveled, and bent inward so that their innermost margins are most approximate and projecting somewhat into the chamber, in order that what passes through these cannot lodge beyond and what strikes upon them will be in unstable equilibrium and cannot rest there. If the inverse form of lip be tried particles will wedge into the slit rapidly, and much difficulty from clogging arises. The slot needs to expand outwardly only to a slight extent, but this is very essential, especially if the lips are thick, although this may in a small degree impair the quality of the spray if the bevel is much extended. To remedy this defect it is better to bevel only one lip, and have that bear a deflector lip or rim to correct irregularities and equalize or thin the spray to the quality desired. Such a deflector may be high or steep, to change the direction of the spray when this is wished, but it must be observed that too much lip is apt to cause drip of the fluid retarded by the adhesion or friction of its surface, or by its resistance from being too steep, which is not advisable. Yet with large broadcast sprays this waste can be collected and returned to the reservoir by Mr. Schier's device, shown in Plate XXIII, Fig. 1, and explained further on; or by an arrangement patented by Mr. Anthony Iske, of Lancaster, Pa., in 1880 (No. 232131), or others. The deflector may be adjusted higher or lower by a movable slide or screw-juncture for the purpose of pitching the spray higher or lower, and for covering part of the slot to lessen or increase its discharge capacity at will. A deflector of this kind is preferably made in the form of an inclined-edged slide or as a bevel-edged screw-band around the nozzle.

Also, the two lips can be adjustable toward and from each other to

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open or close the slot, or they may be entirely separable, better to enable cleaning and repairing. The part of the slot where the pressure or velocity is greatest, as where the injected stream strikes with the most force, should be narrowest, and *vice versa*, to get an evenly-distributed spray. In rotary slit-nozzles the width of the slot should increase somewhat, but very slightly and gradually, in the direction of rotation, as a long, triangular fissure. If the inverse is tried, particles flowing in the direction of the current naturally wedge fast between the lips, but with a gradual expansion in the direction of the movement the wedging along the slot cannot occur so often.

In this class of nozzles, more than in any other, is the use of a rotary body or projectile in the rotation chamber, and caused to whirl around by and with the fluid therein, of value for wiping away and keeping in motion or disintegrating internal foreign bodies tending to lodge upon and clog the excurrent orifice. A rotary brush or any tough body may be used. A pebble, piece of stone, or very hard metal wears off the inner surface of the lips very rapidly, though this process goes slowly if the surfaces are or become very smooth; when a body is thus used the smoothing process progresses quite rapidly, as with metal castings put in a rattler. A pebble thus used soon becomes smoothly coated with the metal. Perhaps the best plan is to use a piece of material softer than that of which the chamber is constructed. Compare Eddy-roses, p. 193.

To be able to observe the internal whirling action the chamber was made with one face of glass. The whirling is exceedingly rapid, tending to produce a vacuum, and certainly generating a rarification in the center which cannot be filled with liquid during the motion. This central vacuity is quite large, and the water appears as a band around its outside. So rapidly does the fluid rotate under high pressure that bodies carried in it are invisible. If a very small body be put in such a nozzle and blown upon, it flies about invisibly fast and strikes so rapidly as to make one continuous sound, but as you blow with gradually diminishing force the sound breaks into a series of rapid ticks, and by looking closely the little body may be observed flying around.

The following are some of the nozzles which have been devised and perfected in my work under Professor Riley, whether for the Entomological Commission or the Department:

In Plate XVI, Fig. 6, is seen a coarse, bevel-lipped side-slot, *s*, in the tubular part, *a*, which bears a cap, *c*, with a beveled edge, which may be set so as to form a deflecting lip to the discharge, or to close it in part, or entirely. Thus is made an adjustable slot, and the cap may be removed, if necessary, for cleaning out. By different bevels, and by setting the cap farther on or off, the spray can be deflected at a right angle, or in planes at various other angles, which may be especially of advantage in spraying upward.

In Plate XVI, Fig. 7, a similar nozzle is shown, differing chiefly in the use of a plug, *c*, in place of a cap, and having the deflecting rim oppo-

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sitely inclined, and formed by the end of the tube at *s*. A nozzle constructed on this plan can be made to throw nearer to the direction of its axis. It should be observed here that in both the above nozzles at least one of the slot-lips is beveled to make the inner edges of the lips more approximate, and these same edges should preferably project slightly inward to make clogging less liable.

Allied to the foregoing is a third form of nozzle, as shown in Plate XVII, Figs. 1 and 2. It differs from that in Plate XVI, Fig. 6, chiefly by the cap possessing one or more slots, *s*, of its own, with lips beveled oppositely, so that either can be set as a deflector, and shut or partially close the corresponding tube-slot by being set back or forth. A nozzle of this kind combines all the deflecting advantages of both the styles just described. Probably the best way to construct this is to let the deflector lips on the outside be formed by the margins of the cap *c*, on the one side, and of a band, *r*, on the other, these parts being either independent or narrowly joined at one or two or more places by a drop of solder, or by a small narrow piece bridging across from one to the other. Such a bridge may be turned to where it will divide the tube-slot into two, and in this manner two or more separate sprays are produced from the same nozzle. A similar nozzle is inversely constructed by having the inner slot in a hollow plug, the outer lips formed by the rim of the ensheathing tube, and with a band fixed to, or independent of, the same, to combine with either of the two sides of the plug-slot.

I find that a very simple way of holding a deflector lip to a tube and its outlet is to clamp it beneath a rubber band or rubber tube slid on as a sheath. For example, a flat piece of sheet metal can be conformed to the surface of the tube or nozzle, and then have one end bent up or beveled as a deflector, while the other end may be shoved under the rubber sheath, which will hold it in place. The plate can be pulled out, or replaced, or adjusted, and when not needed over the discharge, it is carried under the opposite end of the rubber. Of course metal sheaths or partial bands can be used similarly, and a very good plan is to use for a side clamp a spring ring soldered or riveted fast at one point and elsewhere free, but severed on the opposite side with inwardly beveled ends to clamp the lip-slide. A similar ring attached to the lip serves well for fixing it.

The principle of rotation may be introduced with advantage in all the preceding chambered forms of slot-nozzles by making the supply entrance eccentrically parallel to a circumferential tangent to the rotation chamber. I have made cheap sheet-metal nozzles, involving this principle, after the plans indicated in Plate XVI, Figs. 1 and 3. In Fig. 3 the spout, *a*, enters tangentially into the chamber, *c*, being soldered to it at *x*. Near the outside of this juncture is the cross-slot, *s*. The chamber is formed of two concave pieces, or can be short, cylindriform, and may have, for cleaning out, an opening closed by a can screw or otherwise.

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But it will be simple to make the spout, *a*, so short that obstructing matter may be removed through it.

In Fig. 1 is seen a similar rotary nozzle, but with a slot, *s*, following in its cylindrical periphery. The slot increases in width in the direction of rotation (from right to left) for reasons given above. The screw-cap *c* affords a large entrance to the chamber. I have used this same kind of nozzle, made of brass, in the more compact form shown in Fig. 2, where the opening above is by a screw-plug, *c*. The plug may be solid or it can be hollow and have a slot also. In this case it may be set by screw or otherwise towards either of the outside lips, which then serve individually as deflectors or for partly closing the inner slot to thin the spray.

Nozzles of this kind may have the rotation chamber of small diameter, even as small as that of the supply tube as shown in Plate XVI, Figs. 4 and 5. Of these, Fig. 5 has its discharge on the side, at right angles to the spout, and is for spraying upwards, while Fig. 4 exhibits a nozzle for direct sprays. In this figure is also presented a plan-section of the latter. The lettering is the same for the three figures. The slot is marked *s*, the plug, *c*, the spout, *a*, and *o* represents an eccentric entrance, admitting the liquid from the spout, *a*.

These rotary slot nozzles are very compact and convenient, supplying the spray in any direction desired.

The nozzle shown in Plate XVIII, Figs. 2 and 3, presents some other additions which may be made in this class. The spout, *a*, leads to a chamber, *h*, formed by two plates or caps, *c*, held together by the screw or thumb-screw, *w*. One or both of these may have a part of one edge cut away to leave a slot-like outlet between them, as at *s*. Here it will be seen that the outlet grows wider in the direction of rotation, and one lip has a bevel beyond which it shows a deflector-rim in section at *p*. A free, loose projectile, *t*, whirls with the liquid inside of the annular chamber, to wipe away or disintegrate any obstructing materials which lodge upon the interior of the slot. It is preferable to unite the screw fast to one cap, which then answers as a thumb-head for it, while the other works as a nut. By unscrewing, it can be opened. In Fig. 2 the same parts will be seen, and it differs in having the slot continue entirely around between the caps, which do not at any point quite meet, by their margins, but are held thus apart by a central column penetrated by, or formed on, the screw. With a low deflector this would throw a circular or dish-shaped spray, but with the rim, *p*, higher, as shown, the spray is thrown in a bowl-shaped form.

After this consideration of the more essential principles pertaining to slot-nozzles we are prepared to judge better of the value of various kinds that have appeared in the trade.

SIMPLE SLOT-NOZZLES.—The practice of squeezing the end of a hose to flatten the jet of water into a spray has long been in vogue, and the

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thimble shaped gas-jet which discharges through a slit across its end is another early simple form of slot-nozzle used for spraying liquids.

In 1874 Mr. J. H. Fowler, of Oakland, Cal., patented (No. 153672) a slotted thimble-nozzle with the end flattened and broadened somewhat to enable greater length of slot, and hence throw a larger volume of spray than the simpler thimble form, but the shape is such as to render it very liable to clog, and there is no easy way for cleaning it out.

A slot-nozzle of this description, but having a crook so that its discharge is at a strong angle with its supply pipe, has been claimed, with some other pump-details, by Mr. W. W. Mallory, of Holland Patent, Oneida County, N. Y., in patent No. 237193, February 1, 1831.

Mr. Anthony Iske, of Lancaster, Pa., patented (No. 232131), in 1880, a nozzle, consisting of a slot in the side of a small box which is perforated by a supply tube having an inlet hole from its side into the box. The bottom of this chamber has small leak-holes. The drip from these and the slot collects in a large cup beneath them and mounted on the same tube. This principle also looks like a poor one, but I have not had an opportunity for testing it, and hence cannot speak with certainty.

PLUG SLOT-NOZZLES.—Mr. A. F. Allen, of Providence, R. I., patented in 1869 (No. 89456) and in 1872 (No. 132617), what may be called a plug slot-nozzle, the latter patent having added an internal gate-valve to shut off the discharge which would generally not be needed in spraying poison. The water is spread by a conical plug held so loosely in the discharge orifice that a sheet of liquid can issue all around it and break into a spray. The plug is attached by small rods to a nut which screws back and forth on the outside of the nozzle, by which the plug may be set tight enough to close the end or loose enough to let out a sheet of liquid of any thickness desired. With a different plug a solid jet alone or a solid jet and spray combined is made by the same nozzle.

A slit-nozzle involving some of the principles in Mr. Allen's nozzle, some in Mr. Ruhmann's improved cone-deflector, and others in Mr. Johnson's grooved plug-nozzle is called "The Niagara Lawn Sprinkler" and is being made at Sacramento, Cal.* The cone deflector serves as an adjustable loose plug, to change the quantity of water emitted around it. A rod through the axis of the nozzle barrel projects beyond the discharge, where it is cut with a spiral thread, on which the truncated perforated cone can be screwed and placed at such distance as to regulate the size of spray desired.

Mr. F. T. Pinter, of Schulenburg, Tex., patented (No. 233431) in 1880 a nozzle having a semi-funnel-shaped discharge, and fitted into the same a semi-cone as a plug set farther in or out by a clamp screw. The curved narrow space between this plug and the concave wall is the out-

*See Treatise on insects injurious to fruit, &c., of the State of California, by Matthew Cook, Sacramento, 1881. Figure and description on p. 46.

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let orifice, having a curved-slot shape. The device is essentially a crooked adjustable slot, but such that, when set wide open, its lips act only as deflectors.

REMOVABLE SLOTS.—A slit-nozzle manufactured under the joint patent (No. 251448, Dec. 27, 1881) of Messrs. P. Long, De W. C. Vestal, and A. F. Merigot, of San José, Cal., consists of a screw-cap having a large round perforation through its top, beneath which a slotted circular disk can be clamped on the end of a pipe. Disks with slots of unlike capacity are separably insertable to produce sprays of different sizes. The same arrangement permits clogging material to be removed.

JAWED SLOTS.—Attempts have been made to combine the slit-spray and solid jet in one nozzle. Most of these are not well suited for our purposes, but I must notice one which will answer well for large broadcast sprays. This is sold in the market under the title of "The Boss Nozzle" as patented (No. 208122), in 1878, by G. N. Raymond, and G. B. Perkins, of Bridgeport, Conn. It is shown in Plate XVII, Fig. 5, and in section at Fig. 6; *b* represents its hose attachment, *a* the barrel and *c* its head, through which the passage is controlled by a faucet-plug, *d*, so cut that it may be turned by the head *d* to direct the water through the solid jet-pipe *f*, or through the slot *s*, at will. This slit allows the water to spread broadly and the plug is adjustable to flatten the spray still more to any degree of thinness desired, or allow it to discharge with the full capacity of the slot. This adjustment enables the washing or cleaning out of foreign materials instantly from the slit, simply by turning the plug, which is one of the greatest advantages in this nozzle.

A solid jet, with lips that close to form a slot-spray, was invented by Mr. L. B. Smith, of Chelsea, Mass., and secured in 1881 (No. 245096). A section view of it appears in Plate XVII, Fig. 4; *a* indicates the barrel upon which a long thumb-nut, *b*, may be screwed backward or forward. The two peculiarly shaped lips, *yy*, with sides, *cc*, are hinged, at *oo*, upon which joints they may open or shut. The lips also have backward lever arms, *xx*. The nut screwed forward beneath these, holds the lips shut, leaving only the slot outlet, while moving the nut back to disengage it from the levers allows the lips to open and a solid jet is discharged. Similarly the slot can be opened to permit obstructing matters to wash out of it.

In 1874 (No. 153977) Mr. Biddle R. Moffett, of Swedesborough, N. J., patented the nozzle shown in Plate XVII, Fig. 3. "The spout, *a*, is cut under suitable inclination, and closed by rubber or other packing, *b*, applied to the similarly inclined front end of a spring-lever, *l*, which is pivoted to standard, *f*. The packing, *b*, is of elliptical shape, and fits tightly over the spout of the nozzle, so as to prevent the escape of any water therefrom. A band spring, *u*, acts on the handle of the lever, and forces the front end on the spout until opened by pressure on the lever handle, *l*, or on its lip.

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For the purpose of watering, the nozzle is held in one hand and the spring lever depressed by the other, so as to produce the release of the packing and the escape of the water. The water being thrown out with certain force, impinges on the front packing of the lever, which stands at a certain angle with the direction of the water and causes thereby the deviation from its course and its spreading into a broader sheet. The water is thrown to a greater or less distance from the spout as the lever is opened more or less."

In case the discharge-crack clogs, it can be suddenly sprung wide open and the obstructing particles as quickly washed away. It should also be observed that the packing projects to serve as a deflector and thus make the spray thinner. Somewhat similar to this are the three following styles:

Plate XVIII, Fig. 1, shows a modified plan of nozzle which was made by Mr. Williams, of Selma, Ala., and used on his pump noticed further on. The water-pipe, *a*, opens into a chamber formed of a can-screw, *c*, upon a saucer-shaped base, *s*. These are soldered together only in the region marked *x*. From this to *s* is an open crack out of which a sheet of water is thrown and spread still more thinly by striking the upwardly inclined rim, *s*. The pressure of the water inside tends to force said crack open wider, but it is set and held at any width desired by the thumb-nut, on a bolt which perforates the base and has its head soldered to the cap above. When the nut is removed, the cap bearing the bolt can be unscrewed and taken off, leaving the top open for removing clogging materials from within; but generally the crack will clear itself if the thumb-screw is loosened a little to let it gape somewhat wider for an instant.

Mr. Ruhmann caveated two nozzles shown in Plate XVIII, Figs. 4 and 5, combining principles already seen in the two just described. Each consists of a spout, *a*, with its diagonally cut end covered by a plate, *p*, which is partly soldered fast, as at *x*, and partly free, the free part being adjustable to and from the end to open or close the intervening crack, *s*, whence the liquid is ejected. In Fig. 4 this adjustment is by the thumb-screw, *t*, working through the stiff arm, *b*, and having on its point a knob-like expansion inside of a discoid elevation seen on the plate, *p*, enabling the plate to be pulled from or pressed toward the spout by working the screw for changing the size of the spray and allowing solid accumulations to wash out. In Fig. 5 is a different arrangement for the same purposes. Here the plate, *p*, has attached to it the lever, *b*, passing loosely through the fulcrum, *f*, and operated by a person's finger upon the end, *b*, while it is capable of being set close or wide by the thumb-screw, *t*, working against the spring, *r*.

Mr. F. T. Pinter, of Schulenburg, Tex., has recently sent to the Agricultural Department a nozzle very similar to those just described. The flexible half of the plate is a separate piece and only attached to the other half by a small piece of spring metal across the center of the

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juncture. This holds the plate off from the diagonally cut end of the spout while it may be depressed to diminish or close the outlet by screwing down upon it a flanged thumb-nut. Also, the tube crooks near the plate so that its stem or handle is parallel to the course of the spray. Its operation is not essentially different from that of the other nozzles just noticed.

A slot-nozzle patented in No. 223402, January 6, 1880, by Mr. J. W. Stanton, of New York City, consists in a solid jet pipe with one-half its barrel longitudinally cut off at its discharge end and for some distance back so that the thumb can there be applied against the side of the stream to flatten and disperse it.

SIDE SLOTS.—The diagonal slot-nozzles have led us naturally to those which discharge from a slot in the side. Of this kind I have tested two or three different styles devised by Mr. John Schier, of Ellinger, Tex. Plate XVI, Fig. 8, shows his simplest sort, which is a vertical screw-cap, with a horizontal slit cut near its top. The slit, *s*, is so deep as to throw a broad semicircular spray, while that in Plate XVI, Fig. 9, differs only in having the spray divided into three with intervals between. In this way the one nozzle may be made to supply three rows without wasting much spray between them. Either of these short cap nozzles can be screwed on the end of a vertical discharge pipe, and in case of clogging can be removed by unscrewing them, while their shallowness makes the interior easily accessible. A third nozzle by the same inventor is represented in Plate XVI, Fig. 10. The part, *c*, is screwed on and separable from a screw fixed in a solid core, filling the center and one side of the tube, *a*. At one side of this core is an upward slot-like passage leading to the horizontal outlet, the lower lip of which is the top margin of the spout, *a*, while its upper lip is the lower margin of the cap, *c*, and hence the lips are taken apart when those parts are separated. This gives better opportunity to clear out obstructions from the horizontal outlet and the vertical, semi-cylindrical slot within, which may also choke unless a very perfect straining process is used. The lever, *t*, is a thumb-piece by which to screw the short tube, *a*, on a pipe, and the vertical collar at its base is to prevent any poison from spurting back toward the same, which points toward the operator.

Mr. J. C. Melcher, of Black Jack Springs, Fayette County, Tex., has furnished two varieties of this type of nozzle, which are very simple in construction, and may be briefly described as follows: The first is a simple T pipe of tin, with two slots cut crosswise of the tube and parallel with each other just opposite the juncture of the stem-pipe. The ends of the cross-pipe are closed, one having a cork or plug removable for cleaning out the interior. The other nozzle is a simple L pipe forming an obtuse angle and having its distal end closed with a crosswise slot near thereto. For comparatively coarse broadcast work these forms may be employed, and any of the coarse side-slots answer for powder-blasts discharged beneath the plants. See Pl. XXVII, Fig. 4, *ss*.

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DEFLECTOR NOZZLES.

(Plates XIX to XXIII.)

Under this title may be noticed nozzles such as spread a solid jet by a projecting inclined surface against which it is forced. The deflector is generally used for jets of liquid, but it is also applicable for spreading, directing, and dividing blasts laden with dry insect powder. The employment of a beveled or inclined lip as an auxiliary in slot sprays has already been noticed, but in the group of nozzles which is to be considered now the spray is produced by the deflector *alone*.

I have found that good cheap deflector nozzles are easily made by cutting the plates out of thin sheet brass, copper, zinc, or tin by means of a pair of stout common scissors, or by tinner's shears, by then bending in the curves as described below, or as indicated in Plate XX, while the deflector is adjustably or separably attached very easily and satisfactorily by inserting its stem between a solid jet nozzle and a segment of elastic hose or an elastic band tightly surrounding the same.

Over the many punctured and slotted nozzles described above, these have the advantage of possessing only a single round orifice, usually of such size as to be less liable to choking. At least so much is true of large jets for spraying broadcast over a number of rows; but jets of this class from force-pump pressure and small enough for single rows or for poisoning from beneath are peculiarly adapted for clogging by the diminutive size necessary to give only the very limited quantity of liquid needed. On this account it may be impossible to adapt this device quite satisfactorily to the process of poisoning from beneath.

On the other hand, for surface sprinkling, it works very much better, though lacking the highest degree of fineness. But in all cases the lip resists the fluid after it is freed from pressure, thereby retarding it slightly and causing a little to waste by dripping or falling in large drops unless forced with uncommonly great velocity. To avoid this the plate should be polished exceedingly smooth and bright and not allowed to rust. Also the jet must be thrown against it with great force, otherwise mere adhesion of the thin, outspread film of water to its surface, especially if the stream be small, causes some waste by dripping. Since there is no adhesion of water to fatty substances, I have tried greasing the plate, which helps to avoid friction and adhesion of water as between metal surfaces. Certainly there seems to be less drip when it is applied, while it may help to prevent rust from forming. Also an additional pipe terminating in a funnel beneath the plate to catch and return the waste to the reservoir can be used with these broadcast sprinklers.

The lip-nozzle as commonly made with a single jet has a flat deflecting plate with a curved outline or a straight distal edge in the same plane or slightly turned up. The spray from these naturally forms denser and heavier in its center, becoming thinner towards the margins,

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which are not thrown so far as the median part. For throwing poison solution upward, especially into trees, this may be preferable; but for throwing it horizontally broadcast, less direct distance and greater width with more perfect outer margins are needed. There are nozzles for our purposes that thin the middle of the spray by a median prominence of the plate, and there are others which do not thin the middle but contract the margins by turning up the sides of the plate; but these two features should be combined in one and the same plate and should run together by a regular undulation. Such a plate may have various adjustments, many of which are shown in the patterns to be described.

In some of the styles to be noticed it will be seen that it has been the aim to use with a solid jet pipe a deflector so adjusted that it may be set entirely out of the way of the jet, and, in some cases, to give a variable pitch to spray it strongly or slightly as desired.

The following are some of the forms of deflectors used: Those in Plate XIX, Figs. 1, 2, and 3, I employed chiefly for spreading the large air-blast jets of powder-poison blown from pipes about 3 inches in diameter. The deflector plates, *p*, shown in these figures, stand at a variable angle of about 45° from a vertical and the end of the horizontal spout, *a*, is cut at an inverse angle of 45°.

Fig. 3 represents one consisting of the spout, *a*, and an angle-plate deflector, *p*, attached below, at *x*, and above by the rod, *s*. At *f* is an incision with the corners bent outward to divide the jet into two lateral fan-shaped sprays, projecting them in nearly opposite directions into two rows from a single spout ending between them and near the ground.

Another pattern presented in Fig. 2 produces similar effects on the jet. Its median part, *f*, is bent up into a high fold which is closed at the lower end and soldered into slits, at *x*, cut above and below in the extremity of the spout, *a*. The upper part of the fold, *f*, should be closed for a continuous spray, but to divide the one into two it may be opened somewhat. The lower angles, *v v*, are curved to direct upward and thicken the outer margins of the spray.

The latter feature is more strongly produced in the similarly constructed nozzle appearing in Fig. 1 which condenses the sides of the spray still more and works equally well.

In order to get an even fan-shaped spray without ragged thin borders the contracting of the outer margins by bending the outer edges of the plate upward is as important as the thinning of the median portion of the spray by elevating the middle of the plate, and these two features appear in combination with each other in some of the deflectors below. There are three other patterns by which it is easy to make these of sheet metal.

One of them is shown in Plate XX, Fig. 4. The plate, *p*, has its median part elevated at *f*, while the lateral margins, *h*, are curved over.

In Fig. 3 the peculiarity consists in having the distal end of the plate, *p*, not cut straight across but, with an angular piece cut out, fish-tail-

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like, with a short slit, *f*, in the middle, while to each side of it the front edge is bent upward, more steeply at the center but less and less towards the outer angles where the common level of the rest of the plate is attained and beyond which the margins of the plate roll up. In case the water escapes through the central slit badly it may be bridged over by a drop of solder on its back.

The third form, Plate XX, Fig. 1, by which similar results have been obtained, is the most satisfactory. In it there are no corners, the front edge, *f*, being rounded and moderately elevated to an angle approximating 35°, but more or less variable with the pitch of the impingent solid jet. Although the upturned sides, *hh*, somewhat condense the outer margins of the spray thus made, they are thrown as far as the central part because of their encountering less resistance, for the forward margin toward the middle retards more and deflects the fluid strongly toward the sides.

The form shown in Plate XX, Fig. 2, with a straight slightly upturned front edge, has been used by some in preference to the older style with a plate entirely flat; but while it retards the central portion most it does not spread this part strongly enough and has the fault of retarding also the sides somewhat and deflecting them more than the center, whereby they are thrown less distant and made thinner when they ought instead to be condensed slightly in a lateral direction and be not at all impeded in front, for the rule to be established for throwing a deflector-spray of equal quality, density, and distance from the center to the outside is to hold or deflect the sides somewhat toward the center, and the denser center somewhat toward the sides.

The nozzle shown in Plate XXI, Fig. 1, was patented by Mr. R. Hollings in 1853 (No. 9520). The loose ring, *o*, surrounding and pivoted, at *ss* to, the discharge end of the hose pipe, *B*, bears the triangular deflector plate, *A*, and the lever, *H*, by which the plate may be tilted up or down. A spring, *c*, tends to elevate the lever and depress the plate, but the thumb can be used in opposition to the spring to alter the pitch of the same at any instant. The same changes can be made more slowly by turning up or down the screw, *D*, operating upon the lever through the link, *E E;* but the screw is especially for the purpose of holding the plate more steadily at the angle desired and without any manual effort. This device without the screw is presented in the descriptive catalogue (p. 221, Fig. 159), of Messrs. W. and B. Douglas, of Middletown, Conn., with the statement that "Fig. 159 shows hose-pipe with our improved sprinkler on it."

Similar adjustments appear in a more compact and hence more convenient device patented in 1873 (No. 142719) by Mr. Amos Nickerson, of East Somerville, Mass. In Plate XXI, Fig. 2, the flat plate, B, has its lateral margins turned up and is pivoted, at *c*, to the hose-pipe, *A*. The plate is set at the angle desired by the thumb-screw, *D*, working through its very short lever arm, at *s*, and against the pipe, *A*.

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Mr. J. T. Hayden, of Cambridge, Mass., secured in 1878 (No. 205267) the pattern in Plate XXI, Fig. 3. It is a hose-pipe which discharges from the plug-hole, *c*. Beyond the plug, B, is a shortened barrel, so expanded that the plug, B, as shown in section, can have its passage, *c*, set to discharge against the side of the short barrel, which then serves as a deflector, and spray is thrown from a concave, semicylindrical portion of its surface.

Another simple device for this purpose is that in a patent issued in 1881 (No. 238295) to Mr. J. W. Killam, of Lakewood, N. J., and presented in Plate XXI, Fig. 4. The scoop-shaped plate, D, is provided with a socket, B, which can be forced over the jet-pipe, A, when a spray is desired, or may be removed to use the solid jet.

Recently the nozzle presented in Plate XIX, Figs. 6 and 7, manufactured by Mr. P. C. Lewis, of Catskill, N. Y., along with his combination force-pump, described further on, has come to our notice. The adjustment of the small deflecting plate, *p*, is admirable. The plate extends backward beneath the spout as a narrow slide-bar, *p'*, through the loops, *u u*, of the rings, *r r*, and terminates in a bent eye. By pulling this back with the finger the deflecting part of the plate, *p*, is drawn under the end of the spout, to which it clings firmly by springing up tightly against it. Thus the unimpeded solid jet is used, and the same may be instantly converted into a spray by pushing the plate forward. This deflector is very small, neat, and well made of brass. The front edge is rounded, but in the same plane with the rest of the plate, which is very narrow, with its sides nearly parallel. The spray is of a form suited better for sprinkling trees, windows, and houses, but for broadcast work on the ground or over low vegetation a square and broader spray without ragged borders and with the margins and median parts equally dense would be preferable.

One of the deflectors, sent by Mr. J. Schier, of Ellinger, Tex., is represented in Plate XIX, Fig. 5. The median prominence of the plate spreads the water more towards the margins and thins its center. Thereby is sought a spray of greater width, with its middle made as thin as its sides. The back of the tin plate is stiffened by an additional layer of tin and a thick mass of solder, while its neck has a short brass screw attachment, *a*, to the spout.

Another of a similar pattern, but entirely of brass, has the plate detachable so the solid jet may be used when desired as in Fig. 4. The deflector, *p*, is soldered to a ring, *u*, which may be unscrewed from the spout, *a*.

Mr. J. A. Barrett has secured a patent in (No. 239305) 1881 which seems to cover the foregoing idea, or the principle of dividing the jet into a spray by an angular deflector shown, at *a*, in Plate XXI, Fig. 5, where its edge is represented as projecting into the jet, *s*, from the hose-pipe, *e*, upon which the shank, *b* and *c*, of the deflector is clamped by the spring, *d*. It is asserted that "no backward flow or general spattering of

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the fluid is occasioned about the orifice of the pipe or about the sprinkler." The waste which falls as drip from other nozzles is thrown to some distance in the direction of the spray, which is certainly more agreeable to the operator.

In Mr. Ruhmann's improved atomizer, Plate XXII, Figs. 2 and 3, we see one of the oddest nozzles of this class; *b* represents a cone held by a rod, *c*, to the pipe, *a*, in such position that the axis of the tube and cone have the same direction, while the apex of the latter is at the center of the solid jet, which spreads equally over the surface of the cone and the more expanded basal rim, beyond which it is projected as a hollow cone-shaped spray of equal density on all sides. These cone-deflectors can be used in broadcast sprinkling.

A very simple nozzle of this group is the one in Plate XXII, Fig. 1, which pertains to Mr. Binkley's machine, described hereafter. It consists of a jet-tube, *d*, squirting against the flat inclined plate, *e*. In his machine a row of these is arranged on a cross-pipe at just such distances apart that the margins of their sprays meet so all combine to sprinkle a broad strip including several rows.

Mr. John Schier, of Ellinger, Tex., has invented some compound nozzles of this class, as shown in Plate XXII, Figs. 4, 5, and 6. In these, three or four jet-tubes from the same source are made to radiate from each other and strike a semicircular or circular deflector-plate at such angles that the margins of all the sprays coalesce to form one which is very broad and may be semicircular or circular in outline. The details of these need to be noticed more particularly. His earlier form of three-jet nozzle and its mode of attachment is given in Fig. 4, and at Fig. 5 is the same with the deflection-plate disconnected so as to show its adjustment. The nozzles, *c c c*, are connected with the conducting pipe, *a*, by means of a nut, *b*, and throw the liquid onto a distributing plate, *d*, of brass, backed and strengthened by an outer layer of tin. This plate is secured in place by means of a screw soldered beneath the nozzles, running through a tube connected with, and rendered firm by, a bow, *e*, soldered at each end to the outer layer of the plate. The screw issuing from this tube receives a nut; while still greater security is given to the plate by a projection, *g*, beneath which fits onto a tube attached to the nozzle-piece. In this form his three-jet nozzle is attachable to any ordinary hose-pipe.

In 1879 (No. 221617) Mr. Schier patented a three-jet sprinkler differing somewhat from that just described. One modification of it appears in Plate XXIII, Fig. 1, where *p* indicates the rim which is semicircular and mounted on a U-shaped piece, *u*, the ends of which slide through the loops, *ii*, on the vertical part of the incurrent tube, *a*, from which the whole is detachable by drawing the U-bars out from their loops. Above this the knob-shaped nozzle chamber is inserted separably by a screw joint, *x*. The upper part of this can act as a reacting air-chamber or be closed off by a cross-septum just above the three jet tubes, *jjj*, and thus serve only as a knob whereby it may be unscrewed. Like the preced-

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ing one, it is strong, nicely made, and throws a spray of fair quality. In recognition of the fact that sprinklers of this group cause some drip and waste thereby, Mr. Schier has combined with his nozzles a bowl-shaped funnel, beneath the plate, *p*, to catch the drip and return it through a tube, *r*, leading back to the reservoir.

In this connection may be noticed a nozzle patented in 1881 (No. 238430) by Mr. A. J. Polansky, of Fayetteville, Tex., and which seems to be only a simplification of that described above. It is represented in Plate XXIII, Fig. 3, where *h* indicates a nozzle-chamber which can be opened by the screw-cap, *c*, above. There is a central inlet below from the spout, *f*, and outlets, *ooo*, exist at the side, the latter discharging jets somewhat downward to be deflected by the rim, *k*. In the Fig. 4, below, these parts are seen from above, *c* designating the cap and *h* the chamber, which is partly surrounded by the deflector-rim. This at its juncture has semicircular holes, *kkk*, through which the drip from the plate may descend into a pan, *b*, attached by the brace, *l*, and to the spout, *f*. But adjoining the spout, *f*, is a small passage, *x*, from which the collected drip flows down the outer surface of the spout, *f*, to the reservoir. In other forms of this nozzle an air-chamber is substituted for the cap, *c*, to make the spray more constant.

A nozzle having essentially the same form has been made by Mr. Schier and is shown in Plate XXIII, Fig. 2. *a* is the inlet spout, *h* the chamber, *c* its cap, serving as an air-chamber, while *ooo* indicates the outlets and *p* the circular deflector-rim. This nozzle is specially intended to screw on top of the upturned end of a pump-spout. It is strong and neatly constructed of brass. Mr. Schier has also produced a cheaper nozzle having a similar plan. A zinc can-screw cap forms the chamber, which has a tin inlet spout and deflector-rim.

All these three-jet nozzles make broadcast sprays of fair quality, but throw too large a volume to be adaptable to poisoning from beneath, and the capacity of their outlets cannot be reduced sufficiently without becoming so small as to suffer from clogging. The only safe way to diminish the quantity of the spray in such nozzles is by reducing the number of outlets.

CENTRIFUGAL NOZZLES.

(Plates XXIV, XXV, and XXVI.)

Centrifugal sprinklers expand the jet by giving it a rapid rotary motion, which, by the centrifugal force generated, throws the fluid into a shower of particles. Several styles of nozzles come under this heading, as, 1, *Eddy-chambered*, 2, *Fistular*, and 3, *Spray-wheeled*.

Among these, those of the first sub-group, the Eddy-jet nozzles, are the best. For broadcast sprays those shown in Plate XXV, Figs. 5 and 4, Plate XXVI, Fig. 1, and Plate XXIV, Fig. 1, are particularly recommended. For single-row spray-jets applied above or beneath the foli-

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age those in Plate XXV, Figs. 1, 2, 3, 5, and 6, are preferable. Descriptions of these appear in the text below.

When the extension piece or nose-piece of a spray-pipe is removed, a broad spray of better quality is produced. This I regard as positive evidence that in centrifugal nozzles a long discharge passage retards the rotation and deflects the parts of the current more nearly toward parallelism with each other and with the main axis of the passage, thereby loosing the centrifugal or spraying power and producing a narrower, poorer spray. By far the most perfect spraying effects are obtained by the Eddy-chamber with an immediate axial discharge from its face. There is no better established principle in mechanics than that for dispersing purposes the immediate discharge from the wall of a chamber is far superior to a pipe or barrel discharge.

EDDY-CHAMBERED.—Eddy chamber jets are produced by new spraying devices invented and developed in the progress of the commission work. They possess a chamber usually of disk-like or annular shape. There is preferably for our present purposes a single inlet which discharges into the chamber in an eccentric direction parallel to a tangent to its circumference. Such a device gives to the fluid forced into it a centripetal geometrically involute course, very completely converting the in-current projectile or translatory velocity or motion into velocity of rotation apparently increasing toward the center, which generally has an immediate discharge by an outlet through the face of the chamber and not by a long pipe. The fluid within proceeds in an inwinding course approximating parallelism to the thin lips of the outlet, so that the tendency to preserve this direction by its momentum after being freed disperses it in the form of a whorl of diverging tangents from the lip margins, as roughly indicated in Plate XXIV, Fig. 1. The principle of inwrapping centripetal deflection with little or no axial movement until the outlet discharge is reached is one of the special characteristics of the Eddy jets. Thereby is gained an intense rotation at the discharge, and a broad, fine spray therefrom.

The velocity of rotation produced in these nozzles is remarkably rapid, as exhibited by experimenting with one having a glass-faced chamber to show the action within.

The single round excurrent orifice is the largest possible for the quantity of fluid thrown, and hence is less liable to choke; yet it is still better in the Eddy jets proper from the fact that the intense rotation does not permit a solid flow of fluid from the outlet, but only a hollow jet is emitted, which allows the hole to be larger than the body of fluid passing through it. If the face has much thickness the outlet hole through it should have its margins beveled on one or both sides to give a broader spray; also if it expand gradually, like the flare of a bugle, adhesion to the thin film of water passing out against its circumference spreads the liquid much wider. And again, if the bevel or flare is such that the outlet is narrowest at its inner commencement, or if this edge project some-

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what sharply into the chamber as well as into the beginning of the outlet passage, there will be less liability to clogging.

While clogging seems reduced to a minimum in these nozzles, in view of the fact that any nozzle may be filled with rubbish, a removable face, cap, or plug in combination with the rotation chamber is used for those of the small size, but the necessity for cleaning need not occur if proper attention is given to straining with devices such as are described elsewhere in this report.

The advantage of using only a single entrance to a nozzle is easily seen. One large orifice for the given volume of water to be thrown is less likely to choke than two, each of half its capacity. On this account, and in order not to increase friction, more than one inlet should not ordinarily be used. But, on the contrary, most of the rotation nozzles that have been put upon the market have at least two inlets, and suffer from clogging more than twice as much as they otherwise would. To avoid the same impediments it is also desirable to have the inlet or inlets as straight as possible and eccentrically parallel to a tangent to the outside of the rotation cavity; yet, a curve is not specially objectionable in this passage if it be in the direction of rotation, as shown in Plate XXVI, Fig. 4, for it then may serve rather as an auxiliary thereto. The best form of inlet is the straight, tangentially inserted tube or passage in the circumference of the rotation cavity, and this appears in most of these new rotation nozzles, as in Plates XXIV and XXV. But, on the contrary, every centrifugal nozzle that I have been able to find in the trade depends on some objectionable form of entrance passage, retarding the motion, liable to choke, or with passages with difficulty accessible for cleaning out. It should be remembered that a crook equivalent to a right angle, by its resistance, causes over one-third more labor at the force-pump as wasted energy, or, inversely, with the same power at the pump not two-thirds as much spraying power at the nozzle will result.

An entrance-tube at an angle with the axis of the chamber, but tangential to the outside, gives an advantage by adapting the spray for sprinkling from beneath upwards or from above downwards, while it serves well for broadcast throwing also; and it should be observed that in these nozzles which at present seem most preferable for poisoning cotton from beneath, the tangential entrance-tube stands about at right angles to the axis of the spray. At the same time, the nozzle does not project upwards to any marked extent above its feed-pipe, and hence cannot catch upon the plants under or against which it is drawn. On the other hand, the long barrel-nozzles cannot be used for this purpose, because they form a hook or angular projection, which would hang upon the plants.

Certain variations of these characteristics already given will be presented in the examples to be described further on, which show the con-

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struction and what now seems the best combinations of the parts of some of the nozzles of this group.

First we may notice a number of eddy-jets, as involving the principles which seem the best for poisoning the fields, and which are the only nozzles suited for applying poison properly to the under surfaces of the foliage. In all these the rotation chambers and the inlets and outlets of the same are essentially of the kinds already described, but we need to examine a few styles selected and illustrated to show particularly some of the details of construction, form, and size.

Fig. 1, Plate XXIV, presents a plan view of one of the larger typical eddy-jets as cheaply made of thin sheet-metal. The spout, *a*, is shown in section to its inlet-discharge, *x*. The arrows indicate the course of the fluid through the chamber, *c*, and from its central outlet-discharge, *s*. The whorl of tangents is intended to show the plan of dispersion of the spray which flies off from the margins of the outlet, *s*. A plan section of the chamber, *c*, is shown also in Fig. 1, where *x* marks the eccentric inlet and one arrow shows the current of water entering from the spout, *a*, while another gives an idea of the angle of tangential discharge from the outlet, *s*. If desired, the side of the chamber might be furnished with an opening, closed by a lid, cap, or plug. The orifices are so large that clogging and cleaning out will hardly be necessary in nozzles of this size; but when these are reduced for small sprays suited to spraying the under surfaces of small plants, a means of opening the chamber to clean it out had better be provided. A nozzle of this pattern is very cheap, and in the size indicated will throw a remarkably large, fine spray for broadcast work, varying according to the force applied; but with a common syringe pump or hydronette the single jet is easily spread 30 feet wide and distant. Nozzles of this general style seem to be the best for spraying either above or beneath.

To get extremely large and broad sprays the orifices may be increased. As in Plate XXIV, Fig. 2, the capacity of the inlet, *x*, may equal the caliber of its spout, *a*, and the jet-hole, *s*, may be much larger, leaving only a very narrow margin, *c*, to represent the excurrent face. With such an outlet the angle of dispersion is very much wider and the widest sprays for broadcast throwing can be made.

But for all ordinary purposes there is no need of making the nozzle of such large size. Indeed, the very small size shown in Plate XXV, Fig. 4, gives a very large spray well suited for broadcast work. A plan section of the same is shown also. In both figures *a* marks the spout, *x* its eccentric, tangential inlet to the chamber, *c e*, and *s* the outlet. The chamber is formed in a removable plug, *e*, inserted into the cap, which is fixed to the spout, *a*. The tangential inlet perforates both the plug and the cap, while the central outlet perforates the cap only.

A nozzle of the same style, but with a smaller outlet, is represented in Plate XXV, Fig. 2. This and those in Figs. 1, 3, and 6 will exhibit what are suitable standard sizes for small jets to throw poison upward

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beneath the plants. In all these the same letters indicate corresponding parts, and it should be noticed that in the last three the outlet is through the large end of the hollow, cup-shaped plug, while it is beveled so deeply that the inner edge is sharp. If this edge is made to project a little into the chamber, it will be still more free from clogging. These jets will receive attention again further on as combinations in several machines. While they are the best for poisoning the under surfaces of plants, there are some others which might be substituted for the same purpose and work well enough to be worthy of a notice in this connection.

WHISTLE-JETS.—We have introduced another spraying principle in what we call *whistle-jets*, examples of which will now be noticed.

Plate XXIV, Fig. 7, shows an eddy-chamber nozzle, with a peripheral discharge, *s*, from the chamber, *c*, which is closed by a removable lid, plug, or cap, and has a supply-pipe, *a x*. The axis of the chamber is preferably at a right angle with the axis of the spout, *a*, and the diameters of these two parts are about equal. But the tangential inlet-hole from the spout through the wall of the chamber is smaller than the caliber of the spout and is situated close to that side which is marked *x*. The spray is discharged at right angles to the spout, and may be directed horizontally or vertically (upwards or downwards). The internal working and manner in which the spray is generated can be better understood by reference to Plate XXIV, Fig. 6, which represents a plan section of a nozzle having the same internal arrangement, though with the diameter of the rotation cavity, *c*, much greater in comparison with that of the spout, *a*, a disproportion advisable in very large nozzles of this kind. The arrows show the general course of the fluid or powder blast, and it will be seen that the ingoing current is made to bend around to cut through itself to some extent in order to get out through the hole at *s*. This internal colliding on the intercepting of the outgoing and ingoing parts of the current causes the two to cut each other up into a fine spray, discharged at *s*. It is preferable to make the excurrent hole have its side toward *x* depressed lower than the opposite side.

This intersection principle we have already seen as applied in slot-nozzles in the foregoing pages and in Plate XVI. The confliction of two streams outside of a nozzle we have already noticed in Plate XV, Fig. 5, and in descriptions. But one superiority of the present method over these is very evident. The discharge hole being single may have more than twice the capacity of either one of the pair of outlets in the others referred to, hence there is less possibility of choking. Because of this and on account of one current stopping the other, half of the time with a rapid succession of intervals, the outlet can be twice as large as if it threw a continuous jet, and larger still because the jet thrown is not a solid one, but already broken considerably before passing through the outlet. Thus, since only a fraction of the capacity of this hole is used by the volume of liquid thrown, the hole may be two or more times larger

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than for continuous solid jets with the spray produced externally. Clogging is also further relieved by the ingoing jet being forced strongly across the inner face of the outlet, tending to carry past it any obstructing matters, to keep them in motion in the eddy within, as already noticed with the slot-nozzles having interval rotation. And, here again, as there, a projectile or a body whirling on its axis may be used inside, operated by the current to wipe away or disintegrate bodies, which would lodge upon the outlet.

Nozzles made on these principles can be applied as nose-pieces to screw onto the ends of blast-pipes, and discharge at an angle, or they may be formed to throw the spray directly ahead in the direction of the pipe. In Plate XXVI, Fig. 4, is presented a plan-section of this pattern in a shape it may possess either as a nose-piece or as an entire nozzle. The spout, *a*, is purposely made very short. It is attached tangentially to the shell of the chamber, *c*, from which, *s*, is the discharge. In the chamber a partial septum or wall terminating at *x* to keep the fluid from entering the rotation-chamber, until it is conducted around to where it will sweep across the inner face of the outlet, *s*. This septum may be immediately inside the outer shell or inside of an inner shell, forming a hollow shut-off plug as shown.

These whistle-jets work well on blast-atomizers, and also produce a fair spray of liquid, but for the latter purpose it is yet uncertain if they can be made to produce a spray equal in fineness to what is thrown by the true eddy-jets with central discharge.

EDDY-JETS PROPER, as a general rule, have the chamber of a circular form, and the jet-hole ought to be at the center of rotation, which may vary in some instances from the center of the nozzle. The supply-stream, *x*, in the figures already seen, naturally crowds the eddying mass and its center of rotation somewhat toward the side opposite the inlet. A swell can be made on one side of the chamber, as shown in Plate XXIV, Fig. 3, at *x*, to throw the entrance of the supply-stream outside of a tangent to the true circle of rotation, which is bounded by the body of the chamber, but the advantages from this are not so great as to prevent the simpler circular form from being most generally used.

A similar feature appears in the nozzle shown as seen from above and in profile in Plate XXV, Fig. 7. The chamber has a spiral, conoid contour, resembling the form of a cone-shell, but with a central apical discharge. The dotted line shows the inwinding course of the basal margin of its side, which leaves a trifacial inlet-passage on the side, *x*. The spout, *a*, has one end of trifacial shape, and of a size to fit the chamber, which is partly inserted in its end, and joined to it in the line, *x*—*s*. The spray produced is of good quality, but is thrown narrower and farther than, yet not so fine as, from the flat-faced chambers. Nevertheless, where the squirting power is only the gravitation from an elevated reservoir, or is otherwise limited, cases can occur where the given pressure does not give or throw fine spray high enough, and nozzles of this

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form may be used to eject the spray higher. Also, the funnel-shaped cavity directs any choking materials to the outlet, rendering it more likely to clog than is the orifice through a flat face. The top or base may be opened by a lid, plug, or cap for removing foreign objects that obstruct. The construction and plan section shown at Plate XXV, Fig. 6, is very satisfactory. The spout, *a*, has the usual eccentric entrance, *x*, into the conical chamber, *c*, having an outlet, *s*, and being formed in the plug, *e*, removable from the cap, *c*, which is fast to the pipe, *a*. Where the chamber is conical, the more its altitude exceeds the diameter of its base the more coarsely, farther, and narrowly will the spray be thrown, and, inversely, the more the basal width surpasses the height the broader and finer and less distant will the spray discharge, as shown by my experiments with a series of these forms. Rounded convexity or concavity of the discharge-face does not give to the spray any very marked difference from that derived from a plane face, because the part immediately bordering on the outlet in such forms is almost flat. Another form of nozzle, having a shallow funnel-shaped face projecting into the rotation cavity, seems less easily clogged than either of the others.

For some apparatuses it is desirable to have nozzles discharging at odd angles, or with direct discharge, and often with solid jet combinations; hence, some of those which have been made for such purposes will be described.

When it is desired to use a single large spray projected straight away from the person holding the nozzle, the device given in Plate XXVI, Fig. 1, is satisfactory. It is an eddy-chamber with a handle, and represented in section. The incurrent spout, *a*, connects with a hose, and opens by the usual tangential hole, *x*, into the chamber, *c*, which is composed of the hollow plug, *e*, and the separate discharge-face, *f*, held upon the open end of the plug by the cap, *c'*, from which the crown is cut out so as to leave only a narrow border to bind down the face-plate. This plate is removable, and others, with outlets of different sizes, are substitutive for it, to get sprays of all sizes desired. The outlet here shows lips of a form deserving special attention. It is seen to have a bugle-shaped increasing expansion, by which a broader spray can be made than by a straight cut hole, as explained above. The base or plug has its center perforated by a large screw on the handle, *v*, and which can have its end screwed toward or against the outlet to limit the volume thrown, or entirely close the outlet, and thus serve as a shut-off plug.

In the examples so far given we have observed the inlet spout inserted parallel to the plane of the face or base of the nozzle, but it is sometimes advantageous to insert it at an angle with this plane and either on the face or base or periphery. Plate XXIV, Fig. 4, shows one with the spout inclined diagonally upward from the outer part of the face. This spout prolonged makes a very convenient long handle for holding a single nozzle so as to discharge vertically beneath plants.

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When the spout is similarly attached on the base, as in Plate XXIV, Fig. 5, the spray is directed off from the person holding it, which may be preferable for broadcast spraying.

The nozzles so far described can be used independently or *as nose-pieces* on solid-jet hose-pipes or other spouts. In Plate XXV, Fig. 5, *a* represents a common solid-jet hose-pipe with an eddy-chamber screwed on as detachable nose-piece. In such cases it is well to have a nib on the side of the pipe, onto which to screw and carry the end piece when the solid jet is in use. The nose-piece with side discharge will generally be preferred, since it can be also used for underspraying or as a fountain jet, as well as for broadcast work. For these reasons, also on account of its simplicity and freedom from choking, and because it makes with any given pressure a finer spray, it can be recommended as superior to all the other spray-combinations in solid-jet nozzles. In case such an eddy-chamber nose-piece with direct discharge be desired for any purpose it is supplied in what I call the *double-cone nozzle* or double-chamber nozzle shown in Plate XXXIX, Fig. 2, *f*. Its internal construction is similar to what is shown in Plate XXVI, Fig. 2, and described below, but without the adjustability which is not needed in a nose-piece since the hose-pipe has a shut-off plug. Another point worth attention is that these nose-pieces can be used without a solid-jet nozzle by inserting the short inlet-tube in the end of a piece of hose and applying a simple wire wrap.

Examples of other methods of combining rotary spray chambers with the solid-jet hose-pipes should be noticed. In Plate XXVI, Fig. 3, is a longitudinal section of a solid-jet pipe, *a j*, with a shut-off plug, *b*. The passage *n* through the plug stands now at right angles to the pipe and shuts off the solid jet, but it may be seen that the wall of the plug is cut away at *i*, opposite one end of the hole, *n*, to form an excentric inlet, *i*, from *a* to *n* and to the interior of the plug, which is a hollow tubular shell, from end to end. The lower end of the plug is closed and held by the screw-plug *e*, but the upper end has the eccentric tangential passage *x* into the eddy-jet chamber, forming its head or thumb-piece and serving as a spraying device. This chamber has the construction already described, with its spray, *s*, operating in the direction of the solid jet when the latter is closed. The water from the spout, *a*, enters tangentially through the passage, *i*, and rotating inside of the hollow plug, *b*, ascends through the tangential inlet, *x*, to rotate in the chamber, *c*, and discharges as a spray from the outlet, *s*. When a spray is not wanted the hollow plug of the eddy-chamber is turned a little, so that the inlet, *x*, does not coincide with its mate, the shell-inlet. Another shift sometimes of advantage is made thus: The solid plug, *e*, and the hollow plug, *f*, being of the same size, are interchangeable, so that the latter may be used to throw from the base of the plug and at right angles to the pipe a spray for spraying the under surfaces of plants, or such that it can be set upward anywhere as a fountain. This gives a better spray than that from the

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top of the plug, since the latter has more crooks in its supply passage and hence requires more force to produce the same effect.

The following throw both kinds of jets, but have no right-angle discharge. The adjustable parts of one, involving an eddy-jet, are shown in Plate XXVI, Fig. 2. The eddy-chamber, *c*, is without an immediate spout, but has an inwinding, peripheral wall, leaving the inlet, *x*, and a much depressed side from *x* to *a*. Its discharge is at *s*, and on its opposite axis may be fixed a packing and shut-off plate, *j*. There are several variations in the construction of this whole arrangement, but, as shown here, the eddy-chamber is really a spiral septum, and its side toward *s* has no wall but that of the outer cap, *c*, against which it is held by the water-pressure upon its base, *j*. Thus it is inclosed in another chamber formed by the cap, *c*, having a corresponding discharge, and being screwed upon the hollow plug, *e*, which has a central inlet, *a*. The inner rim of this plug is shown to have projections which hook upon corresponding processes of the basal margin of the eddy-chamber, *c*. The opposite passages, *a* and *s*, match each other, as do the two opposite screw-sockets, *ww'*. These parts being the same, they are reversible, so that either end may be used in turn as inlet or discharge. When *w* is used as a hose-socket *s* is the spray-outlet, or a solid-jet pipe may be screwed into the socket, *w'*. And, inversely, *w'* may serve for a socket, while the jet is thrown from the opposite end. In this case the internal rim-projections should interlock inversely.

The operation of this device may be explained as follows: Supposing the water is injected at *a*, it passes across through the inlet, *x*, to eddy in the chamber, *c*, and discharges as a spray, at *s*. Screwing the cap, *c'*, farther on the part, *e*, the eddy-chamber and its base piece, *j*, are pressed toward or against the inlet, *a*, as a shut-off, to close it and stop the jet entirely or lessen its volume to any degree desired. On the other hand, screwing off the cap, *c'*, until the face, *s*, is carried away from the hanging chamber, *c*, the water takes the less circuitous course, *j c s*, across the outside of the eddy-chamber, and, without whirling, issues as a solid jet. By another arrangement in the same nozzle the solid jet is passed straight through the center of the base of the eddy-septum at *j*; but many details cannot be described here. The inlet passage being simple and of good size, there is little susceptibility to choking in the nozzles described above, and the parts are separable, so as to be easily accessible for cleaning out. A cheaper construction for this nozzle can be had by using can-screw caps and the other parts all of sheet-metal. All the effects are about the same except the shut-off adjustment, which for force-pump nozzles is usually not needed.

There are also other modifications and combinations of the eddy-chamber, but I have noticed enough for the purposes of this report.

FISTULAR.—Several *Fistular Spray-nozzles*, known as hose-pipes or barrel nozzles, that may alternately produce both kinds of jet from the same barrel, have been patented, but the fact is that the attempts to

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combine a spray and solid jet in the same nozzle have resulted in constructions which are injurious to one or both of the jets; yet it may be well to notice briefly what has been done.

One of the simplest barrel nozzles for spray and solid jet combined was patented (No. 29994) January 31, 1860, by Mr. N. Hotz. The barrel is of two segments joined by a pipe-nut allowing the rotation of either segment upon its own axis and independent of the other. The ends are both closed at their juncture, each having a diaphragm thereat perforated by two corresponding holes. The proximal septum is preferably of leather. When the parts are turned so that the holes are exactly superposed one upon the other the liquid passes through in two streams, which immediately meet to form a solid jet; but when these holes overlap only slightly the currents through them are rendered somewhat diagonal, and they join to form a spiral stream that gradually disperses as a spray of rather coarse quality. When turned so that the holes do not overlap each other at all, the passages are entirely shut off.

A hose-pipe operating on the same principle is that claimed by Mr. P. O'Neil, of Kalamazoo Village and County, Michigan, No. 219505, September 9, 1879.

Messrs. J. Clifford and J. Gielow in 1877 (No. 191934), Mr. J. Clifford again in 1880 (229521), and Messrs. J. H. Johnson and F. A. Hoyer in 1881 (No. 237386), all of Chicago, Ill., patented nozzles having some form of core or septum movable back and forth to shut off either one or both of the two kinds of jet. The water is diverted around this core to enter the barrel, which discharges it as a spray or solid jet. Two or more eccentric inlets to the barrel introduce in it the rotation. A single inlet would be preferable, as I have already observed. The lack of a central passage through the core, as an unobstructed way for the solid jet, is an obstacle to both jets, but mostly to the solid. A nozzle having this same objection and a single crooked passage for both jets was patented by Mr. W. M. Clarke, of Newark, N. J., in 1881 (No. 248555), which, as now made, is illustrated in longitudinal section in Plate XXVI, Fig. 5. The piece, *n*, turns snugly in the shell, *z*, and is held therein and prolonged by the piece, *w*. There is no direct passage, but all the water must pass around the septum, *j*, through the course, *x r x'*. The ends of this arched passage are shown as communicating fully with the holes, *x x*. In this position a solid jet passes through; but when the outer shell is turned so that the holes mentioned only coincide by one-half their area or less, the discharge into their barrel, *i s*, is eccentric, and causes a rotary spray of fair quality, the volume of which can be graded by turning farther or less.

Most rotary spray-pipes that have come to my knowledge use a cross plug. Three of these, one patented by Mr. J. W. McGaffey, of Chicago, Ill., in 1870 (No. 170753), one by Mr. J. H. Johnson, of Chicago, in 1877 (No. 198515), and another by Mr. J. W. Gray, of Hartford, Conn., in 1878 (No. 203539), have a so-called "3-way plug," having a large hole

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for the solid jet and two smaller ones with crooked passages, which conduct the water into the barrel in such an eccentric manner as to cause rotation and a resultant spray. The narrow crooked passages are easily clogged and not readily cleaned except in the case of the one last mentioned, which is pictured in section in Plate XXVI, Fig. 6. The plug hole, *c*, directly connects the hose passage, *a*, with the barrel, *i—s*, except when turned in the position shown, where the spiral grooves, *e e*, give the eccentric spray streams. These grooves being cut entirely in the plug, any accumulations in them will be pulled out with the plug when it is removed for cleaning, which gives some advantage over the others. This is the plan of the so-called "Faery pipes" which are now for sale by the trade. Mr. John Gielow, of Chicago, Ill., patented in 1877 (No. 187123) a hose-nozzle producing the rotation by a spiral worm-passage through the center of the plug above and at right angles to its smooth bore, which does not appear to have any special advantages.

Mr. C. B. Hosford patented in 1881 (No. 237684) a hose-pipe having beyond the plug an annular stationary core with an objectionably complex, eccentric course for producing rotation and choking.

SPRAY-WHEELS.—Spray-wheels form a group of very different centrifugal water-throwers including several fountain jets constructed on the principles of Barker's mill and as oblique-faced spatter-wheels all moved by the force of the jet, but none of these have proved of practical value for our present purposes.

Allied to these are the centrifugal machines operated by power and noticed hereafter as brush-throwers, whirling-reels, fans, and toothed fans in the groups of throwers of poison, &c.

II.—CENTRIFUGAL THROWERS.

[Plate XXVII.]

In this section I present some results of my study and experimentation pertaining to the use of rotary brushes, reels, &c.

The sprinklers and dusters in this group are driven by hand-power or machinery, and thus originate the motion of the poison, which receives no other impulse. These should not be confounded with wheel-nozzles, among centrifugal nozzles, where the motor power was already imparted to the poison before it reached the wheel, which, instead of giving motion, only somewhat retards and deflects that of the poison, and this by its impact operates the wheel from which it flies off. The devices here to be noticed throw the poison by rotating tubes, reel prongs, brushes, or recesses.

Among these the brush-throwers promise most. They are not so liable to clog as are the common sifters and many-punctured sprinklers.

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Yet these in turn are *surpassed by the blowers* treated in the following chapter.

ROTATED ORIFICES.—If a tube supplied with water, even without water pressure, be whirled, the centrifugal force will cause the water to flow through it and fly off from its distal end in the form of a circular broadcast spray. The devices I have contrived to test the possibility of utilizing this principle show that it can be used for coarse sprinkling and that sprays may thus be easily thrown 25 or 30 feet wide.

PRONGED REELS.—When liquid is allowed to flow onto the axis of a group of radiating, whirling prongs of wire or other material, a centrifugal action appears in the fluid following the prongs causing it to fly off from their extremities, thus producing a circular shower. As such reels and stiff brushes grade into each other, they may be noticed further under the following paragraph.

BRUSH POISON-THROWERS.—If a brush of any sort be supplied with fluid or dry poison, and its bristles be sprung, their elastic recoil imparts a centrifugal force to the material which will be thrown in a spray. Also if a cylindriform brush, or one of any other shape, be rotated rapidly, the centrifugal force will disperse the poison fed to it, whether the bristles be sprung or not. Utilizing these principles some machines have been constructed which promise much, and will be described hereafter. The following kinds of fiber have been tested to get their relative values in brushes for this purpose: 1, broom corn; 2, stout bristles; 3, tampico; 4, so-called sea-root; 5, spintered woods; 6, split goose quills; 7, whalebone; 8, coarse hemp; 9, wire.

Any of these answer for sprinkling or powdering from above, and, where plants are very low, for poisoning from beneath; but where poison is to be thrown from below upwards into plants as tall as cotton, the more stiff and longer fibers answer best. Broom-corn proves the most satisfactory for throwing powder on account of its length, strength, elasticity, and cheapness. In these brushes the straws or bristles should not be inserted densely, but ought to have plenty of room to flex and recoil freely. A very good size for the brush is 7 inches diameter and 4 or 5 inches in length.

Very stout hog-bristles work well, but are almost too expensive. They throw a finer spray than broom-corn, but not so far. Also the moisture destroys their stiffness and elasticity more than that of the corn.

Tampico brushes throw powder and liquid nicely, but the fiber is not durable enough. It loses strength and breaks off or wears out too soon.

The so-called sea-root brushes work only tolerably well. The material is as strong as broom-corn and somewhat similar in appearance, but its fiber has not the length, stiffness, and elasticity of the latter.

Quills from geese or other fowls will also answer. They should be split in halves, or thirds, or quarters, and inserted with shellacked pegs into a cylindrical wooden core or hub. The quills soften greatly, from being wet, and hence lose their stiffness and straightness very soon if

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split very slender. Altogether, they cannot be regarded as equal to the better materials mentioned above.

Whalebone is in all its properties similar to the quills and far too costly for use.

Coarse hemp from untwisted ropes is very cheap, and though much inferior to corn for large brushes it works pretty well in small brushes and will probably be employed in them to a considerable extent.

Ordinary broom wires (1^{mm} diameter) arranged sparsely into a brush with the tips about 1 inch apart throw a very fine spray.

This and steel wire and broom-corn are the materials which now seem to be preferable above the others named for use in these brushes.

Rattan, bamboo, and splintered woods can be employed, but they have not yet been found very satisfactory.

As a rule brushes having considerable velocity of rotation throw a spray better and farther when the bristles are not sprung. If the bristles become permanently curved from being continually sprung in one direction the brush may be turned end for end to reverse the bristles, and then when rotated in the same direction it will work better than ever. Brushes of some materials often need to be changed thus.

Cylindriform brushes of suitable shape are made and sold for brushing horses and polishing fine metal work by the Stow Flexible Shaft Co., Nos. 1505 to 1509 Pennsylvania avenue, Philadelphia, Pa., and probably by others also. But such brushes made by the usual process of drawing tufts of the fibers or bristles into holes in a hollow core or hub, which is afterward plugged, are very expensive and a still worse feature is that they cannot be made with a small core.

Small, even brushes, with symmetrical form, are made best and most economically, as in Fig. 2 of Pl. XXVII: In a cylindrical solid core turn out deep cir cular grooves separated by narrow rings of wood. The fiber is looped under a wire, whichis wrapped tightly in each groove, and drawn through a saw-cut across to the next one, &c. The brushes are thus made in the simplest and quickest manner, and the price is a small fraction of what the old-process brushes cost.

Soft brushes for cleaning glasses, pitchers, &c., are already manufactured on the similar plan of drawing bristles into spiral grooves. But by this method the ends of the brush cannot be made square.

The bristles of the brushes should be very sparse. If they are not far apart the water is lifted and thrown in masses which have adhered between them. Also the greater the velocity of rotation the fewer must the bristles be. When quite high motion is used, a very few, inserted with shellacked pegs into awl-holes in a wooden cylinder will answer. Home-made brushes are easily constructed on this plan, and it is an easy method where spring wire is used instead of fiber.

The rotating brush may be fed with liquid by allowing it to drip from a small tube onto either the periphery or axis or side; but usually the most satisfactory and convenient method is to supply the liquid within the

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circumference on the ascending side. The objection to feeding at the center is that, on account of gravitation, the spray is thrown more downward than upward, whereas the ascending side entirely opposes gravitation, and throws off the material before it is carried around to where gravity can pull it off downward.

If the brush be rotated in a cylindrical trough supplied with the fluid, the latter is dipped out and thrown in too great volumes, unless the quantity in the trough be kept at just such depth that too much cannot be caught and lifted. To keep thus a constant shallow supply in the trough it may be fed by the automatic drip process, such as is employed in automatic inkstands, &c. A tube from an air-tight liquid reservoir descends into the trough near to its bottom. The height of this drip orifice gauges the depth of the liquid; for when enough flows to submerge this outlet air cannot enter it to press the liquid out, and only after the brush has thrown out enough to lower it can more air enter and the liquid again flow to the same level.

This process is a little more difficult and complicated than the free drip method, in which the trough may or may not be used. In the latter method the amount thrown is gauged by the size of the smallest caliber of the feed spout.

Brushes may also be used as feeders or throwers of powder. They may be used on sifters, to keep their small passages open and help rattle the powder through them. Also a brush may be worked in a powder reservoir or hopper to feed out the powder upon plants or into a blast from a blower, to be swept thereby to the substances being injured by insects.

These brushes will throw powder to some distance and in an excellently diffused cloud, but quite fine powder, like flour, &c., cannot be thrown very far through the air, because the particles are so small as to have little momentum, and soon become stopped by the resistance of the atmosphere; but coarser powders, like corn meal, sand, &c., are thrown a much greater distance by the same force. Yet in either case much more distance can be attained by encasing the rotary brush, or reel, or wheel, in such a manner that it may act as a blower, and throw a blast of air along with the powder. The stronger the blast the farther the powder will be thrown, and the coarser the powder the sooner will it fall. In these respects it is seen that the thrower-discharge is the opposite of the blower-discharge.

Some machines involving the use of brushes need to be noticed here. Plate XXVII, Fig. 1, represents in plan section a brush-machine of simple construction, and illustrates a method of encasing rotary brushes to be fed by powder or liquid, and in order to throw the same by the elasticity of their bristles springing from beneath a surface against which they are revolved.

The cylindriform brush *d*, turns (in the direction indicated by the arrow) in a trough open on the side, *s*, and bears the square powder-can,

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P, above. The bottom of the can is perforated like a grate with parallel slits, through which the bristles act, at *x*, to feed out the powder and to carry it around to *s*, where they spring from under the catch, *o*, to throw it forth in a cloud. The broader the slits in the base of the hopper the faster will it feed, and the amount to be used can be gauged by their width, which will vary some for the different kinds or mixtures of powder. The base, *x*, of the powder-can or hopper, *P*, may be attached only at one side, and there by a hinge, so that the brush, in rotating against it, will cause it to shake, and thus help the feeding process. Also a stiff part may be added to the brush, or its axle, to jar said base more effectually at each rotation.

These devices are superior to perforated sifters, since they do not clog, while they throw a wider cloud. Also they may be used to throw powder upward, but not to a great height, for in this respect they are inferior to the blowers. This method is, however, applicable to poisoning cotton, potato-vines, &c., and worthy of being used in simple and compound machines. Brushes arranged in the same way will throw a spray of water, which may be fed as described elsewhere. The most satisfactory of these ways is to have it drip from a spout without the automatic process.

If the elasticity of the fibers is to be used, they should be sparse and turn slowly. If the throwing is to be done by the centrifugal force arising from rotation (which does better than by the elasticity), the velocity of rotation should be high (1,000 revolutions per minute or more). The brushes rotated at 2,000 revolutions per minute made such a breeze that powder and liquid could not be fed onto them at the circumference. This was remedied by a circular disk of sheet metal placed on each end of the brush, and having the same diameter, to prevent the air from feeding into the brush by central suction at the ends. Also, with high velocity, the fibers should be exceedingly scattered and of the stiffest sort. By this method, stiff wires, inserted so their points stand about one inch apart, form a reel, which works better than the corn-brushes.

Mr. L. N. Wisewell, of Ottawa, Ontario, Canada, patented a brush machine in 1878 (No. 211075), and which is illustrated in Fig. 3 of Pl. XXVII. As shown, it possesses a form adapting it to poisoning potato-insects; but with some alterations a machine on similar principles might be constructed for poisoning cotton. A wheelbarrow is used as the motor and carrying device. The friction wheel, *i*, on the spring arm, *g*, is held against the side of the barrow wheel, being rotated thereby, and communicates its motion through its mandrel, *f*, pulley, *j*, and its belt, *k*, to pulley, *l*, and its axis, *c*, bearing the arms, *b b*, which act as agitators to keep the poison mixed in the tub-shaped reservoir. The liquid flows out through a cock, *q*, and its hose, *p*, into the semi-cylindrical cups, F. In these cups are the rotary brushes, *n*, made to whirl by the band, *k*, driven by a rim on the barrow wheel. The whirling

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brushes throw the poisoned liquid as a spray from the cups. I have not seen the operation of this machine, but judge from a similar device, arrived at independently and experimented with, that it contains a principle which in a modified form will be of some value in poisoning cotton-insects.

The following statement should be appended here. In speaking of the means of applying Paris green in water to the cotton crops, Dr. George E. Gillespie, of Natchitoches, La., reports:

"The mode of applying it differs according to the means of the planter using the poison. Many persons make brooms of mayweed (*Anthemis cotula*), which are handy and very convenient; others use the common garden watering-pots."—Bull. No. 3, p. 125.

ROTATED RECESSES.—These, in the ends or sides of rotated bodies, may be used to throw liquids and powders in a centrifugal manner. Where such devices whirl very rapidly it is difficult to feed them satisfactorily upon the periphery, and I found of most value a sheet-metal funnel with internal radiating septa. This is rotated rapidly while supplied inside with a dripping stream.

After devising and using simple apparatuses to test the spraying powers of rotary throwers of the various kinds noticed in this chapter, I concluded that another class of machines was superior, and hence stopped the study of such throwers to take up that of blowers, which follows.

III.—BLOWERS OF POISON.

Poisonous gases, vapors, liquids or powders, as insecticides, can be applied by means of various blast-discharging or blowing devices, and examples of apparatuses for such purposes will be noticed below.

ROTARY BLOWERS OF POISON.

[Plates XXVII, XXVIII, XXIX.]

In order to show the efficiency of rotary fans for blowing poison I designed several different styles, including simple machines to be worked by hand, as well as a compound one for horse-power. Most of those made and tested proved successful.

The power required to drive one of these fan-blowers is so slight that the lightest band-wheels and gears will answer, and when operated by hand only the slightest effort is necessary. The velocity needed is rapid, yet not exceedingly high, but should preferably equal one thousand revolutions or more per minute. The difficult part of this problem pertained to the devising of a practical method of feeding powder or fluid by a regular and gauged supply in small quantity into the blast in the encasement or spouts of such blowers, and to the production of suitable distributors to deliver the laden blast upward into the plants in a simple and efficient manner. With reference to the kind

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of material to be blown, these machines may be noticed under two heads; (1) *Rotary fans for blowing powders* and (2) *Rotary fans for blowing fluids.*

The hand-blowers shown in Plate XXVIII, Fig. 1, and those in Plate XXVII, Figs. 5 and 6, have proved the most satisfactory that I have devised. Of those invented by others, none have yet proved to be very practical or successful for field usage. My experience indicates that the oscillating bellows blowers, with the improvements described below, are preferable to rotary fans, but that the latter may yet take a high rank.

ROTARY FANS FOR BLOWING POWDER.—In considering these, it must be remembered that the poisons are commonly mixed with other powders as diluents, some of which, as flour for example, refuse to flow readily, and pack together over the hopper outlet to clog it, so that an arrangement for feeding these more difficult substances as well as the poisons proper is necessary. The various forms of hoppers used in machinery are not satisfactory for the slightly adhesive or cohesive substances which it has generally been found desirable to use. If a hopper has an inclined or horizontal perforated base, even with a very large hole, or if its sides are not vertical, but sloping, flour will not slide down and out in a steady satisfactory manner, even when subjected to the ordinary jolting of a machine hauled upon the ground. A simple hopper that I have contrived for dry poisons and their mixtures, to feed any amount desired, and to do it regularly without clogging, is represented in plan sections in Plate XXVIII, Figs. 1, 2, and 3.

In these Figs. it will be seen that the hopper, *p*, is represented by a hermetic can mounted on the blower-drum, *d*, or discharge pipe, *i*. The top is closed tight, and may be opened by the large screw-cap or plug, *c*, or by a large tight-fitting lid. Its sides are preferably vertical, as shown, and the base is entirely open, as at *x*. Beneath the open base and still larger than the same, is a hanging base or roof, *b*, suspended at its ends by bolts, each through a short tube, *t*, and with a thumb-nut above by which to elevate or lower it. Whether this be suspended in the upper part of a blower-drum or of a spout, the blast can act at its sides and above it along the slot-like openings where the powder rests exposed. The mass of powder and its hanging base can be set deeper or less deep into the blast passage, thus choking it more or less and increasing or diminishing the attritional power and wearing surface whence the blast feeds itself. As the mass of powder thus tends to become undermined more and more, it sinks without clogging or interruption down onto the hanging base, which may be flat or bent throughout or at its margins. It can also have small perforations, slotted or other; but the simple imperforate plate is satisfactory enough, and will probably prove the best and standard form to use. So it will be seen that by setting the base nearer or farther from the powder-blast the quantity may be gauged, and since flour adheres to the straight metal walls of the

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hopper less than it does to flour while its periphery is undermined, the outside of the column of poison will settle down best to where the blast can feed itself therefrom. In case dry poisons or mixtures that are not adhesive, and that jar through the small outlet of an ordinary hopper *too easily* are to be used, their flow may be regulated by a small plate adjustable beneath the outlet and essentially on the plan described above. In such cases it is sometimes preferable to mount the plate on a single screw or support opposite and working through the blast in opposition to the small outlet of the hopper.

Two other plans for hopper-supply are shown in Plate XXVIII, Figs. 4 and 5. These also do not allow the powder to gravitate directly downward into the blast, *f;* but the hopper, *P*, is closed tight above by a removable screw-cap and narrows downwardly. The powder from its lower part has to be acted upon laterally by the blast, at the point *e*, in Fig. 4, and downwardly at *o*, in Fig. 5, where the hopper-throat curves around to open beneath. In either of these cases the communication, *e*, of the blast with the powder may be much elongated and can be adjustably opened or closed by a slide-plate. The latter or the wall instead may have an area of many perforations, similarly located, or a slot or slots for such powders as feed too strongly by other methods. These two forms of hopper I do not find so satisfactory for flour mixtures as are the forms with adjustable base-slots previously noticed for feeding blasts.

Finally, it should be added that powder can be fed by introducing in the vent of the hopper a moving reel, or brush, or rod, as has been shown in other machines, but these add complications and work less satisfactorily than the arrangement presented with the first feeder described above.

The blower drum or casing is preferably made light, of stout zinc, brass or other sheet-metal. It need not be over a foot in diameter, and had better swell gradually in the direction of rotation to its ex-current orifice, as in Plate XXVIII, Fig. 1, *d*, although the true cylindrical form will answer. The head of the drum on one or on both sides should have a large central suction-opening equal to one-third or one-half of its diameter and with a stiff wire rolled in its margin. For making a blast through only one or two pipes the drum should be very short with the heads only 3 or 4 inches apart. This distance can be multiplied by any number of pipes desired.

Pipes for conducting the air blasts should be round, smooth, and bright. Tin suits well when not rusty, but is easily bent, unless of heavy grade. Zinc is preferable, if not acted upon by corrosive chemicals, as it does not rust from the effects of atmosphere and moisture. Oilcloth spouts kept expanded by a spiral of wire 18 feet long proved flexible, strong, and light, but too rough. Friction destroys the blast of the ordinary rotary blower very quickly. Crooks should also be avoided, and are much more objectionable in pneumatic blasts than in

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hydraulic currents. If positively necessary they should be made very obtuse and gradual, preferably as long, smooth, regular curves. The same caution applies to branches or forks in these blast-pipes. The blast may be divided to fork, as indicated in Plate XXVII, Fig. 4, *xss*, and the discharges may be upward or provided with upward deflectors at their terminations. Forks, if long, should be flexible, yielding so as not to hang too badly on the plants; but the double deflectors can be very short and rigid. The deflectors may also be used to spread direct or divide the single blast. For these purposes various patterns and curves may be employed, such as are shown in Plate XIX, Figs. 1, 2, and 3, described above. The forms in Plate XIX, Figs. 1 and 2, are the most satisfactory I have been able to devise for use on these rotary blowers. Their application is illustrated in machines presented in Plate XXVII, Figs. 4 and 5, *gs*. Thus the single blast discharged between a pair of rows is divided and spread laterally and upwards to supply both the rows. By bending the wings of such deflectors or setting them at various angles the discharge can be directed down or up, or wherever desired. It is also important that the deflecting surfaces be kept bright.

Light fans may be made of sheet metal soldered to a wire reel or simply to an axle having each end hung in a strip of metal attached across the head. The axle bears a small gear or pulley ½ to 1 inch in diameter, driven from a gear or band wheel having six times the diameter, and bearing a small hand-crank three inches long, by which the necessary velocity in small hand machines is easily attained. Thus the fans are easily operated, requiring only the slightest amount of force if all the surfaces work smoothly and loosely as they ought. These parts are indicated in some of the figures which may be separately noticed. In Plate XXVIII, Fig. 1, *o* is the crank, *e* the drive-gear, and *n* its small driven gear upon the fan-axis, which is hung in the support, *r*. The radiating fans whirl in the drum or case, *dd*, sucking at *a*, and discharging through the tangential exit spout, *ss*, upon which is the powder-can, *pc*, instead of a hopper, and having a hanging base, *b*, adjustable in the spout, *ss*, by the screws, *tt*, as described. In Fig. 3 is a plain section having like parts similarly indicated, the distinctive feature being that the bottomless powder-can, *pcx*, is mounted upon the drum, in which the shelf, *b*, hangs. This plan of construction is embodied in the machine of Plate XXVII, Fig. 5. It works well and may yet supercede the plan of joining the powder-holders with the pipes. The latter machine is suspended against the side by a loop over the shoulder. The gearing is the same as that noticed above, but the spout is directed downward to the ground and backward, bearing a double deflector to supply the two rows between which the bearer walks. The pipe may hang or drag and can be of any suitable length. When the person is walking the poison may generally be freed very close behind him, as the blast of the machine should direct it somewhat backward and with

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force enough to overcome light breezes. If greater distance is desired additional segments may be inserted. These are easily keyed together by a wire hanging inserted through the joints. By removing the crooked segment or reversing it, the same implement may be used to deliver in advance of the person or in a downward, horizontal, or upward direction with a single or double cloud. This rotary blower can be combined with a wheeled cultivator and be operated thereby. Also a series of such blast-spouts supplied from as many blowers, more economically from a single blower of large capacity, can be combined to form a compound machine.

In Plate XXVII, Fig. 4, is one of these compound machines which I devised for use with a single horse and to supply six rows or two rows and two half-rows as desired. It may yet prove practical to use a greater number of spouts and supply a larger number of rows at each drive; but my experience has only shown that three such spouts can be practically used. This machine was tested at Ithaca, N. Y., and afterwards tried in the cotton near Atlanta, Ga. The thin tin of such a machine is apt to get bent unless very carefully managed. Stout sheet metal should be used for the drum especially. Many dents in the pipes have not proved seriously objectionable. The whole is mounted on an A-shaped frame, *zz*, having three wheeled legs, *ttt*, and is drawn by the shafts or whiffletree in front. The two lateral arms of the frame, *z*, can be set wider or nearer apart upon the cross-bar, *z*, to suit wider or narrower row-interspaces. Each hind leg is a stout section of iron gas-pipe ($1\frac{5}{16}$ inches), screwed or welded to an iron plate on its top, which is bolted to the frame. Its lower hollow extremity is mounted on a swivel-pin, having an elbow extension backward to its wheel. These swivel wheels are intended to prevent side-draft strain, and are especially of value in turning. They need not be large or strong, as the hind parts of the machine have little weight. The front leg *t* is an arch of iron (3 by $\frac{1}{2}$ inch), bolted above, beneath the apex of the frame. Thus it is really a double leg $37\frac{1}{2}$ inches long. To the sides are fastened bars, *k*, extending forward to support the whiffletree, while to the lower extremities are boxed the ends of the revolving axle of the draft-wheel, *w*, and its large drive-gear, *u*. These wheels are respectively 30 inches and 16 inches in diameter. The latter drives a small (3-inch) pinion on the axle of the large (14-inch) band-wheel *j*. These are on opposite sides of one leg, to which their axle is boxed. The band is of very soft, light leather, and whirls the small ($\frac{3}{4}$-inch) pulley *o* with the fans on its axis in the drum. The ends of the casing are bilged to give stiffness, and its outside should be annularly ribbed or otherwise stiffened or encased for protection. The large powder-can upon it is closed hermetically by a tight cap or cork. The three-way discharge must be somewhat downwards, and the pipes should slope down more and more as they advance. It is best to give them a projectile curve. This is for the purpose of keeping the powder toward the upper part of

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the blast and to prevent it from depositing in the pipes, which should terminate near the ground in the manner already described. The median pipe descends immediately, but the two lateral ones are attached along the sides of the frame and to the hind legs, behind which they terminate, as shown. Such a machine is very light, and a mule or even a man can pull it easily. The velocity of rotation will vary from 800 to 2,000 revolutions per minute, according to the speed with which it is hauled.

"The following is a machine, invented by Mr. Charles T. Hurd, of Victoria, Tex. (Patent No. 145949, December 30, 1873). It is intended to be attached to a cultivator or similar machine, and is drawn over one row of plants at a time. It consists of a fan, or blower, inclosed in a cylindrical casing, and conjoined with a box containing the poison. The powder is scattered over the plants by means of a vibrating wire or cloth sieve at the bottom of the box, and at the same time converted into a cloud of dust by a current of air created by the fan already mentioned, and which is operated by a pulley or band running from the axle of the blower to a wheel on the supporting axle of the cultivator.

"In Plate XXIX, Fig. 1 represents a sectional elevation of the apparatus as attached to a cultivator, showing one end of the box A partly broken away; Fig. 2, a plan view, with a part of the blower-box removed; Fig. 3, a rear view of the blower-box and powder-box as attached to the cultivator axles.

"A represents an oblong box, tapering to the bottom, which contains the powdered poison, having a flap or door, *f*, on its top, and opening at said bottom onto a wire screen or cloth, *b*, running from end to end of the box, which screen is oscillated lengthwise and across the row of plants by a lever, *d*, pivoted on one side of the box A, and engaged at the other end against a rotating cam, *e*, upon the axle of the blower B. A spring, *l*, keeps the lever engaged with face of the cam. The blower B is confined alongside of the box A in a cylindrical casing, B', of a common form, and is mounted on a horizontal axle, *g*, which ends in a pulley, *h*, opposite to another pulley, *i*, upon the supporting axle *m* of the cultivator.

"The box A and the blower-box form one whole box, and is supported at either end by arms *k k*, which are centered upon the said supporting axles *m m*, for the purpose of allowing the box A to be raised or lowered in the application of the powder. A ratchet or brace, *n*, for this purpose extends from the box A to a convenient part of the cultivator. The orifice *r* of the blower-box opens parallel with or close alongside of the oscillating screen *b*, so that the air current catches and directs the powder against the plants as it is shaken through the screen from the powder-box.

"To confine the powder to the plants and vicinity, side guards or hoods E E, of sheet metal or light wood, as shown by the dotted lines, may be advantageously employed, and be attached to the supports *k k* or other convenient part or place.

"A seat may also be attached to the arch *p* or beams D D of the cultivator for the use of the driver."

"It is evident that this apparatus neither saves material to any great extent nor time in the application of the poison, since only one row of plants is dusted at a time. The only possible advantage it can have is in so distributing the poison in a fine dust that it attaches to the under side as well as to the upper side of the leaves"; yet this is not effected so well as it will be done by machines discharging the powder blast in

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an upward direction. The method of feeding the powder to the blast looks as though it cannot prove satisfactory.

"Some suggestions made by the inventor as to the use of his machine for applying vapor and fine spray of liquid poison will be found mentioned further on."*

ROTARY BLOWERS OF LIQUID.—In endeavoring to produce rotary fans for blowing poison fluids the most difficult part of the problem pertains to feeding them to the blast. Since a blower will throw out any amount of fluid that is allowed to flow in, and this as fast as it enters, the quantity admitted must be limited to only so much as will make a spray of the quality and size desired. Also, the less fluid the finer and farther will it be blown, and if the supply is too great it will be dipped out or splashed in great masses or very large drops, which are not thrown far but wasted. To regulate or control this three methods prove applicable. The first is by means of a rotary brush, as already set forth in speaking of brush sprays. The second consists in reducing the orifice of the feed-pipe from the reservoir to such size that it will conduct just so much as is desired and no more; that is, by means of a shut-off device or a small drip, by which the water enters the drum above so as to fall upon the revolving fans, or at some other point to accumulate in the bottom of the drum and be dipped up by them. The third principle is that employed in automatic inkstands, but applied on a larger scale. The reservoir is air-tight, closed by a can-screw or plug. Its outlet is near its base, and extends through a tube leading into the bottom of the drum, where the fluid can flow in only just deep enough to shut off the entering of air into that end of the tube, while air will be admitted and the fluid pass out only so fast as the latter is lifted out by the fans.

To prevent each fan from scooping up too much, also to divide the water mechanically and ventilate it thoroughly, the dipping ends should be provided with long comb-like teeth. The best results are secured by bending each alternate tooth forward or backward at its base, thus, to make a double row, and then bend forward nearly at a right angle the distal half of each of all the teeth. This arrangement of the teeth is shown in Plate XXVII, Fig. 6, *i*, and is explained below.

The fans, by their rotation, give the fluid a tangential momentum, but the air current is a very important element, as I have shown by using toothed reels without fans on them. They are only equivalent to rotary brushes, which are here surpassed by introducing the superadded blowing power of the fans.

The outlet from the drum should be large. In case it be low down upon the side, many drops will fall from or near it and the water may

* To avoid much repetition of reference to Bulletin 3, U. S. Entomological Commission, the first edition of this work, Prof. Barnard's credit-references to said Bulletin are omitted, so that all quoted matter, unless otherwise credited, is taken therefrom.—C. V. R.

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slop out slightly. To prevent this a hollow lip may be added, as in Fig. 6, to catch the lower part of the spray and allow it to flow back.

In the figure just cited this arrangement, *h*, and the drum *d* are shown in section. The spray-discharge being at *s*, the heavier part of the spray is lowest, and passes into the hollow lip, *h*, thence flowing downward to re-enter the base of the drum at *x*, where the constant depth of water is indicated by horizontal broken lines, and *z* shows the water-inlet, above which the water cannot rise in the drum. At *f* is shown the peculiarity of one of the fans. Its end, *i*, is seen to be provided with teeth or hooks, which alternate in two rows, and each has its distal half bent forward at right angles to the fan. These cut through the liquid, allowing the blast to enter it, and they also cut up, splash, and carry some of the liquid which is blown out at *s* by the blast from the face, *f*, passing outward through these teeth or hooks.

A single drum may have two outlets, one near each end, and so throw two sprays at different angles; but the outlet farthest in the direction of rotation should be much the largest, to give an equal spray, as shown in one blower, which I planned for this purpose.

Unfortunately, my experience shows that a rotary-blower blast carrying a fluid spray cannot well be divided, or have its direction changed, by pipes or deflectors, because its impact against any surface that would alter its course condenses the spray there, so that it is left from the blast and flows down.

It is easy to use these machines for sprinkling in a horizontal direction or from above, but to throw up underneath the foliage of low plants they must be carried very close to the ground.

There are various ways of conveying and operating these blowers, and the following machine will serve as an example:

Mr. D. E. Darnell, of Masonville, Burlington County, New Jersey, has lately obtained a patent, No. 254804, March 14, 1882, on a rotary-blower apparatus, for distributing insect poison and fertilizers, that merits attention in this connection. It appears in Plate XXVIII, Figs. 6 and 7, and consists of a barrel, *a*, rotary agitator, *c*, a rotary blower, *n*, with a belt, *s*, and train of gears, *f*, *e*, *h*, *j*, driven by the rotary axle, *d*, of a pair of wheels that carry the whole machine, which is drawn by one horse in shafts. By a clutch the main wheels are released from driving the gears to throw the apparatus out of action.

It may be seen that the reservoir has the arrangement of a common horizontal barrel-churn, and the rotary dasher, *c*, inside is driven by cog-wheels, *f*, *e*. The gear, *f*, also communicates through gear, *j*, its axle, *k*, the pulley, *l*, and band, *s*, to drive the rotary fans of the blower, *n*. A supply-tube, *t*, leads from the reservoir to the blower-case, which it enters at the horizon of its axle. A cock, *t*, adjusted by the crank seen behind, regulates the outflow. The blower is so hung by the parts *p*, *q*, *r*, that its discharge-pipe, Fig. 7, *n*, may be thereby directed somewhat up or down or laterally. No new principle in the blower proper seems

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to be indicated. The novelty appears to consists chiefly in the adjustable arrangement of the blower, and in its means of combination with the barrel, agitator, and carriage wheels.

"Mr. Charles T. Hurd, of Victoria, Tex., whose machine for dusting has been described and figured on Plate XXIX, Figs. 1, 2, and 3, suggests in his claim that by changing the oscillating screen *b* and inserting a perforated bottom in the box A, and charging the same with poisonous liquid, the latter may be atomized by the current of air originated by the blower, and thus applied to the row of plants over which the apparatus is drawn."

This is virtually the combination of a rotary blower with a many-punctured sprinkler, and the recognized faults of the latter have been already given in discussing the disadvantages of many-punctured nozzles from their clogging, &c. The blasts from rotary blowers are not intense enough to be valuable for atomizing. From the construction shown in this machine it is evident that the spray from the perforated screen would be carried by the blast, but not that the blast would atomize it finely; also, the downward course of the spray is not suited for reaching the under surfaces of the foliage.

"Finally, in this connection, it is well to state that Mr. Hurd suggests that with some slight change his machine can be converted into a vaporizer, so as to throw a jet of poisonous vapor on the plants.

"Another rotary-blast vaporizer " was invented by Dr. M. Perl, of Houston, Tex. (Patent No. 91,365, June 15, 1869), for the purpose of destroying the worms by means of sulphur vapor, and consists, in the main, of a gas-generator, which is placed on a cart, intended to be drawn between two rows of cotton, and provided with a fire-box and a blower worked by means of a pulley.

"The accompanying diagrams, Plate XXIX, Fig. 4, represent this machine, the upper figure being a vertical section and the lower a side elevation.

"Upon the wagon A is placed the gas-generator B, consisting of a fire-box, *c*, separated from lower part of the generator by a concavo-convex bottom *c'*.

"To the upper chamber D of the generator is attached one end of the blower or bellows E. This bellows is provided with a shaft, *d*, upon which are secured metal wings, *d'*.

"On one end of the shaft *d* is attached the cog-wheel *e*, gearing into the cog-wheel *e'*, secured to the wagon-wheel G. The other end of the shaft is provided with a crank, *f*, which is attached to upper end of pitman *i*, the lower end of this pitman being attached to the pedal *h*, secured to pendants *h' h'*, attached to the under side of the axle-tree H. G" is a hose, with a perforated nozzle, *m*, and stop-cock, *n*, which is attached to the top of the gas-generator. M is the chimney.

"The machine can be operated, when in motion or stationary, in the following manner:

"A fire is made in the fire-box *c*, and a certain quantity of sulphur is placed in the gas-generator B, in order to form sulphureous gas. The blower E is set in operation, when in motion, by the cog-wheels *e e'*, and, when stationary, by detaching the cog-wheel *e'* and attaching it to the crank *f*.

"The action of the blower or bellows will not only furnish sufficient air in forming sulphureous gas, but it will also force the gas through the hose to any desired point.

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"Aside of the circumstance that only two rows of cotton are supplied at once with vapor, it is very doubtful whether the worms are killed by sulphur vapor in the open air, judging from its effects on other insects when not confined."

Until some kind of vapor that is practically effective for application in the open air becomes discovered, it will not be worth while to occupy time and space with vapor-machines for such purposes.

FORCE BLAST ROTARY BLOWERS are made for forges, &c., but none has been found cheap enough and otherwise adapted for poisoning-machines. Should such be made, they would probably supersede the ordinary rotary fan blowers, and, perhaps, the oscillating bellows.

OSCILLATING BELLOWS BLOWERS OF POISON.

[Plates XXX to XXXV.]

In considering this group of blowers the more important general results of my study and practical experience with them will be presented at once and thereafter descriptions of a few of the machines. The word bellows is sometimes applied to rotary fans and to reciprocative piston blowers; but the common oscillating leather bellows of our forges are examples of the kind to be specially noticed in this subsection. These are much more powerful instruments than the rotary fans for blowing powder into the state of finely diffused clouds, or for blowing liquids into atomized sprays, while they can also be used to produce an air-pressure in tight reservoirs to force out the liquid contained, whereby a utilizable squirting power is afforded, but almost no pressure at all can be produced with the rotary blowers. Also, these are generally preferable to the latter, because less costly, less complicated, and requiring little velocity, while they allow almost no waste of energy in their operation, are light, and their blast can be conducted great distances through very small tubing, much less cumbrous than the large spouts of the rotary blowers.

Those specially interested in blowing poison should read carefully what follows with reference to the figures of Plates XXXI, XXXIII, and XXXIV.

A main drawback to these bellows has been in the difficulty of constructing them to endure exposure to the wetness of field-work, but this matter is entirely corrected in the strong, cheap bellows here recommended.

These have the heads of wood or sheet-metal and about equal and rounded in outline, while each has a groove in its periphery, into which the stout leather is drawn tightly by thick nealed wire. Thus the leather is held mechanically without needing paste, glue, or nails, and the bellows is constructed more strongly, quickly, and cheaply. The heads are preferably of metal, as wood is apt to cause leakage from shrinking or cracks. There is no seam in the leather, which only overlaps broadly, making it of double thickness to act as a hinge on one side where the two heads of the bellows come together. The incurrent orifice and valve

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may be made as usual. This on the excurrent orifice may be through either head of the bellows, the latter preferably toward the poison reservoir. Across either head may be added a cleat, which also can be hollow, with a discharge or suction passage, and may extend beyond the bellows as a spout or handle. A reacting spring to expand or open the bellows can be placed inside, or else outside between the projecting ends of the cleats, spouts, or handles. Some varieties of these bellows, methods of operating them, and ways in which they are susceptible of being combined with nozzles, reservoirs, &c., will be particularly noticed in the special apparatuses to be described.

OSCILLATING BLOWERS OF POWDER.—Instead of the various hoppers, which generally allow the poison to escape beneath the cover, or permit moisture to enter there when the plants are wet or in case of rain, it is better to employ a water-tight can, closed by a large can-screw cap or plug. The can may be of any convenient size or shape, and any other ordinary reservoir, as a tight keg or barrel with a large bung, can be used in its stead.

The device to supply the blast with powder must be certain to feed continuously and adjustable to apply as much or little as may be desired, yet not capable of clogging. To produce such an effectual arrangement for feeding minimum quantities of poison mixed with materials which pack and clog easily, like flour, for example, was difficult, and for a long time threatened to be an impossibility; but the principles already noticed above apply here, and their employment in these devices is described below; but it must be remembered that the blast of the rotary blower is large and weak, while that of the oscillating blower is small and intense, so some adaptive modification is advisable.

A blast with an independent passage for itself is made to feed itself by the attrition of its lateral parts or by a side blast. Thus the blast force is utilized to cut out and carry the powder from the mass where it is exposed for an area extended by a slot or a group of openings through the segmental or interrupted wall between the blast passage proper and the reservoir which adjoins or surrounds it. Thus a reliable positive feeding force is directed and controlled without depending solely on gravitation or on ordinary mechanical feeding devices, which will not feed regularly in minimum quantities. This kind of apparatus works freely and the direct unimpeded blast throws the powder a good distance. The blast thus acts to open the narrow feeding entrances. At the same time a passage to deliver a part of the blast or another blast simultaneously above the poison to produce a pressure downward upon it assists gravitation, but is not necessarily employed, for, especially where the bulk of the poison is small, the air will alternately and intermittingly force up through the poison, opposing gravity, and then react downward, assisting it. For flour mixtures the feeding is done pretty well by passing the blast tube through the base of the powder-can, therein providing the tube with numerous holes having one-eighth

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of an inch diameter on top of the tube, one-fourth on the sides, and three-eighths on the under side. Where the powder is of less adhesive character the outlets should be reduced in size and number. These holes should be crowded close together, and a slot seems preferable to a row of such holes. In any of these cases a part of the blast in passing should be deflected out or crowded out strongly against or into the powder by some device for directing it, or for choking the main passage to crowd the blast therefrom. Where a series of holes is used, the part of the blast which is forced out through the proximal holes will pass through the powder along the outside of the tube to beyond the deflecting device or obstruction, when it will re enter through the distal holes into the blast passage again and this outside portion of the blast operates upon the powder to feed-in a part of it into the excurrent tract of the main passage, that can communicate to and through an extension tube beyond, which should preferably branch, leading beneath two or more pairs of rows, for the blast may be conducted through the same small pipes that are used for water in squirting-machines. The outside blast in the can naturally follows the surface of the tube, and thus feeds out a thin layer from along its surface without catching and carrying large lumps or masses to clog its passages which lead back into the tube. Also on account of the blast approaching these holes at an angle, nearly a right angle, and thus entering them very obliquely, changing its direction to do so, clogging is less possible, and there is a strong tendency to disintegrate lumps against the distal edge of the hole. Further, in case the more proximate exit-hole or holes, which the blast naturally passes out through at first, should become clogged, it has the alternative of several others, and by thus playing from one hole to another and across the clogged hole to reach the open one beyond, any clogging lump or mass is gradually disintegrated, reopening any one of the ways which may have become clogged.

The device for causing partial obstruction of the blast-passage may be permanent, but should preferably be adjustable at will, to crowd or deflect off through the powder a greater or less part of the blast; for the larger the obstructions the more of the blast is diverted and the greater the amount of powder it feeds out, and *vice versa*. A damper, gate, cock, plug, or any other shut-off device may be used.

When the powder blast is directed through small more or less branching tubes their terminal spray-nozzles are removed, and side holes, upward-curved ends of pipe or deflectors may be substituted. The blast of powder from these generates in the atmosphere vortical rotations, which spread, mix, and diffuse the discharged powder into a cloud large enough to supply a single row, which is all that is needed in powdering from beneath. When desired the powder jets may be expanded more broadly by using very wide-mouthed eddy-chamber jets, and may be divided into forked jets by double deflectors made on the plans shown in Figs. 1 and 2 of Pl. XIX.

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The tubing for conducting the blast must of necessity be small and diminish its capacity one-half beyond each fork, otherwise the velocity will check and some of the powder will be thereby allowed to deposit and accumulate inside, occasionally to be thrown out irregularly when jarred into the blast. To prevent such accumulations any shaking or jarring in the machine will be beneficial, and if the tubes always proceed in a somewhat downward course gravitation will assist.

On this plan is constructed the most practical bellows apparatus yet invented for poisoning fields. There is no possibility of moisture impairing the working of the bellows or reaching the powder in the tight can, clogging is less possible, and the powder may be supplied in minimum quantities beneath several rows.

It is now necessary to describe some machines embracing the principles above set forth, and also, thereafter, a few devices invented for similar purposes by others.

In Plate XXXIII, Fig. 1, appears one of the bellows, *v*, recommended above, as hung upon the end, *c*, of a cart or wagon, to be operated by the wheel, *w*, and to blow poison from the can, *p*, through a system of distributing pipes carried on a frame, which has its part, *a*, supported and conveyed by connection with the cart. The cleat of one head of the bellows is attached at points, *c c*, by hanging hooks or clamp-screws or otherwise. Between the two projecting ends of the cleats is a spring, *s*, to open the bellows. This may be placed inside, but when situated externally can be more easily repaired if necessary. A ratchet, *l*, is hinged opposite the hind wheel at the attachment, *g*, to play upon the spokes and operate the bellows by communication of the rod, *r*, and by the reacting spring, *s*. The blast tube passes through a valve, *o*, to prevent the poison powder or fluid from being sucked backed into the bellows. Beyond this the tube extends through the basal portion of the powder-can, *p*, after which it connects with the branching system of distributing tubes extending to beneath the plants.

This is a very simple motor arrangement for operating the bellows. The same principle may be used with the bellows in other positions, and it can be so set with reference to the wheel that its arm, *x*, shall act as the ratchet, or pawl, upon the spokes, whereby the other parts will not be needed. Also for giving or communicating the motion to operate the bellows any of the more complex mechanisms used for giving reciprocating or oscillating movement may be employed, as, for instance, those for working pumps in the other machines described in this report.

The reservoir and its device for feeding the poison to the blast may be adapted for fluid or for powder-poison as desired, the same blowing apparatus answering for either.

A simple bellows-blower may be combined with any implement drawn in the field, as a plow or cultivator, and so become operated by the horse without effort on the part of the plowman, as shown in Plate

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XXXIV. The base of the bellows is clamped fast to the plow, while its face, *v*, is free to be moved. A spring inside the bellows distends it. The cleat on its head extends as an arm, *x*, which is connected with the plowman's foot, preferably by a jointed rod of stout wire, *n*. A double loop about the heel and instep forms a comfortable and secure attachment to the rod, and has a weak part strong enough to work the bellows, but not with sufficient strength to drag the plowman in case of a runaway accident. When the foot is advanced the section of the rod next to it falls to a horizontal position, while the second section swings forward as a pendulum. The length is such that during the moment while the person's weight is resting on the foot the advancing plow causes a pull on it, and thereby a puff from the bellows, the pull being made by the horse only. A series of such puffs succeed each other, one occurring each time the foot is planted. The discharge from the bellows sweeps through the short pipe, *h*, is fed by poison in the reservoir, *p*, and conducted through the pipe, *t*, which has a flexile part, *z*, and behind the plowman an outlet, *s*, directs it from below diagonally upward into the row. The puffs, which occur at intervals of about two feet apart, spread so broad as to overlap, and thus fill all parts of the row with the poison. As shown, one part of the pipe near its end may drag upon the ground. Instead of this a pair of branch pipes may be used to supply two rows.

A similar bellows apparatus, to be carried by a person, is shown in Plate XXXIII, Fig. 2. The can, *p*, is hung upon the back by a loop passing over the shoulder. The hand-bellows, *v*, may be operated between the hands, or, if it is suspended beneath the arm-pit, by one arm. Its blast-tube extends through the base of the can as a feed-pipe, and so communicates with the pendent or trailing branched pipe, *i g s*, supplying two rows as shown.

Instead of the pendent pipe a pair of hanging branched pipes can be connected with the main blast, and thus the apparatus is enlarged for poisoning four rows at a time.

A person can use this arrangement on horseback. Riding down one middle the branched pipes hang between the two adjacent middles, supplying two rows on each side. For this purpose the hanging tubes must be elongated and flexible.

In Plate XXXI, Figs. 1, 2, 3, 4, and 5, is represented a very small hand-blower, which may be used where the worms appear in small patches. It consists of the hand-bellows, *v*, discharging through the pipe, *h s*, which perforates the base of the can, *p*, and extends far beyond, usually with its distal end, *s*, crooked, so it can be used to throw in an angular direction. This pipe may have two branches, and thus apply to a pair of rows. The device will also be found convenient for treating many plants and insects other than those of the cotton crop.

The figures referred to need to be noticed more in detail. Fig 4 may be taken as presenting the more typical form of this device. It represents

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a small bellows, *v*, with handles, *h h*, one of these serving as a discharge-spout, communicating, through the powder receptacle, *p*, to its delivery at *s*. The bellows is made mechanically tight without nails, glue, or other soluble adhesives, and is very strong. After binding the leather into the peripheral groove of the heads by a stout wrap of wire, a marginal, flange-like projection of the metallic heads, *i*, and the border leather above the wire are clinched down over the wire. Thus the head and leather are mechanically bound together in the firmest, strongest, tightest, and most durable manner. Also, as hydraulic bellows these cannot be surpassed, and where used for spraying liquids, as in devices to be noticed below, or where employed in wet fields or driving rains, this independence of harm from moisture is an excellent characteristic. The suction-valve is a soft plate of leather caged, with little play, upon the inlet hole which is punched through the thin metal head. This hole is covered outwardly with fine brass gauze, *z*, to prevent coarse bodies from sucking into the valve or parts beyond, and to prevent the outward air-pressure from forcing the leather plate to wrinkle or bulge out too much at the inlet. Instead of the many-punctured outer cover one or more slots will give similar advantages in the construction of the inlet. Also, the valve plate is inwardly caged by gauze or bars, preferably by the former. This prevents the valve-plate from moving far off from the inlet, so that it will close quick and never fail to overlap the margins on all sides, and it also preserves the flatness of the flexible valve-plate while allowing the outward pressure to strike its outward surface in a direct manner. Thus the valve is made very simple, light, and effective. The discharge may be taken from either end of the hollow cleat or handle, *h*, but the arrangement shown will generally be preferred, in which the blast is discharged through the left hand, between the powder-can, *p*, and the bellows, *v*. Thus the weight of the bellows tends to balance that of the powder-can and extension-pipe, rendering the tool more easily wielded than if the weight was more distant from the hand. The powder receptacle may have any suitable form, but the bicone shape here shown is efficient, and seems the simplest to make. One end is truncate, opening by the large screw-cap or plug, *y*. The blast passage inside extends radially from the periphery to the apex, with an extension-pipe, *i*, beyond, terminating in the crook discharging at *s*. The extension piece is separable at *r*. The internal relations of the blast to the powder will be better explained by observing Fig. 2, which is a sectional view taken longitudinally through the parts. The tube, *e r*, inside the can, has a slot in its side, and about midway in its passage is a shut-off device, *j*. When this is set, partially closing the tubular passage, only a part of the blast goes through direct, and the rest is crowded out to grind away the powder exposed by the slot passages. The more of the blast thus crowded out, the more of the powder will be fed to and carried away by the blast. To allow this feeding by erosion, one, two, or more slots or rows of holes of size and

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shape to suit may be thus made, whereby the blast can act upon the powder in the base of the can. Another view of the same device with an extension-pipe having additional crooks appears in Fig. 3. The lettering has the foregoing explanation so far as it corresponds. Fig. 1 presents a side view showing the device without its extension-pipe. In this form, or with a long, straight extension spout, it may be well used in broadcast powdering. To the discharge, *s*, may be combined a flexible hose communicating with a free, stiff pipe, which can be independently directed, as desired, in broadcast work or in powdering trees. This is particularly desirable when the bellows is conveyed on a vehicle and operated by the foot or by machinery. Also, however, the bellows may be worked or conveyed backward or downward, or a trailing extension-pipe may be used with stiff or flexile branches such as have been described elsewhere. When the apparatus is hauled it is advisable to have the powder receptacle much larger in proportion, of course, and with a differently shaped base, yet with the same internal construction. Another variation in the small hand-machines is shown in Fig. 5. One head of the bellows, *z*, is secured flat against the side of the can, *p*, which has the form of an ellipsoid cylinder. This makes the apparatus very compact and all in one piece, as it were. By such an arrangement the blast-tube curves back at *e* to pass through the base of the receptacle. Otherwise the machine is not essentially different from those already noticed.

The following machines devised by others need to be noticed here:

In Plate XXX, Figs. 1, 2, and 3 represent a machine invented (No. 178704) by Mr. S. D. Allen, of Philadelphia, Pa. In the Report of the Department of Agriculture, on Cotton Insects, p. 247, it received the description below:

"Fig. 1 is a side view of the device; 2, an enlarged vertical sectional view of part of the same; 3, a transverse section on the line 1, 2, of 2.

"The poisoning compound is contained in a reservoir, A, and is forced in small quantities at a time through a spout, *a*, by means of air forced into the reservoir from a pair of bellows, D, or other blowing mechanism, to which are connected arms, BB′, by means of which the bellows may be operated, a spring, *e*, being attached to the end of an upright, *f*, to serve or assist in distending the bellows. The apparatus is mounted on a wheel, *s*, which imparts motion to the bellows through the medium of a rod, *p*, and studs *n*, on the wheel. By each stud the rod is drawn downward until it is freed by springing away from the stud, when it will rise by the action of the spring *e*. The outer end of the lower arm, B′, is adapted to a segmental rod, *g*, and is provided with a set-screw, by tightening which the arms and bellows may be confined in any relative position to which they may be adjusted as shown, for instance, by dotted lines in figure 1. The reservoir, A, is provided at one end with a funnel, *d*, through which the material is introduced into the reservoir, and at the opposite end is an inclined spout, *a*, over the end of which is fitted a funnel-shaped guard or shield, *b*, which protects the end of the spout and prevents the clogging up of the same when used among wet foliage.

"The object of making the spout inclined, as shown, is to enable it to discharge either up or down or on either side, as desired, without changing the position of the bellows, D, the change being effected by merely turning the reservoir around on the nozzle, *m*, of the bellows until the spout is pointed in the proper direction.

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"The reservoir, A, is divided in the present instance by two longitudinal partitions, *i i*, which break up the contents of the reservoir and prevent them from accumulating in the lower portions of the same—openings *j j*, however, allowing such communication as will permit the entrance of sufficient material into the lower portion of the reservoir to supply the place of that expelled at each blast of the bellows, thus insuring an even discharge of the whole contents of the reservoir.

"In order to cause the air to act only on the portion contained in this lower division the nozzle has an inclined face, *n*, in which the perforations for the escape of the air are formed, the air being thus directed against the bottom of the reservoir, and carrying with it a small quantity of the contents, which are expelled through the spout, *a*. A perforated disk, *x*, is inserted into the entrance of this spout to assist in distributing the contents evenly."

Mr. Thomas Woodason, of Chicago, Ill., is manufacturing some small insect bellows having the construction of the common sanding bellows. In Plate XXXII, Fig. 3, is represented one of the best made by him. The powder is introduced into the double cone-shaped reservoir by a cau-screw opening above. A valve prevents the powder from sucking into the bellows at its neck. The blast-pipe from the bellows projects into and beyond the center of the reservoir, where its end is closed completely. The air can only pass from this supply pipe in a lateral direction by a number of perforations. The feeding device has no adjustability. The powder pours into the discharge-pipe if that be directed downward, and the feeding is affected by shaking and jolting, yet in its way, though at some mechanical disad vantage, it does very fair work as a distributer of poison.

Mr. Woodason also makes a similar bellows with the common feeding device, shown in Plate XXXII, Fig. 2. The powder-box is a funnel with its top closed, while its outlet communicates into the blast-pipe. It feeds less regularly than the preceding one, especially when flour mixtures are employed.

Another interesting blower for broadcast powdering is that patented (No. 56558) in July, 1866, by Mr. J. W. Hendley, of Washington, D. C. This machine is illustrated in Plate XXXII, Fig. 1. It was used as early as twenty years ago for blowing powdered sulphur as an insecticide upon plants, but has sold in the trade chiefly as a "sanding bellows." The bellows proper is of ordinary construction, but the spout and feeder are peculiar. The latter is a can which oscillates up and down on and with the upper or movable head of the bellows. A flexible segment in the neck of the feeder allows the can to move independently of the neck, which leads into the blast-spout at a point just beyond the bellows. Inside of this neck is a barbed rod having its upper end fixed in the can, so that the movements of the latter make the rod act as a plunger and rattler in the neck to push the powder along down to the blast. Just proximal of the feed-entrance the blast-pipe has a short crook to help prevent the powder from getting back into the bellows, while distal from it there is a flexible segment with an adjustable clamp to set the discharge end at any angle desired. The exit end is broadly flattened, having a slot-like discharge orifice to spread the blast.

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Mr. J. P. Stelle, of Citronelle, Ala., thus described, in his report in 1880, a simple device which he had tested:

"It consists of a small, round tin box affixed upon the pipe of a common hand-bellows, the box sitting at right angles with the pipe. The top is perforated with numerous fine holes. London purple undiluted is to be placed inside the box and forced up through the perforations by working the bellows."

Its poor feature is that wetness can enter the perforated face to affect the powder, and the outlets may clog, for the best time to apply dry poison thus is when the plants are wet.

Several small hand-blowers are in the market, but most of them are adapted only for killing bed-bugs and insects on house plants.

OSCILLATING BLOWERS OF FLUIDS.—This application of the bellows promises to be of much importance. It affords the best obtainable blast for atomizing and blowing fluids. The blast atomizers I have devised and described below make mists of excellent quality and embody what seem to be the best methods of charging, directing, and discharging the blast with liquid.

Special attention should be given to the machines presented in Plate XXXI, Figs. 7 and 8, and in Plate XXXII, Figs. 4 and 5, described below.

To prevent the bellows from sucking back (the liquid to be blown to atoms, or the air) from the blast-tube into itself, the blast leaving the bellows is passed outward through an excurrent valve.

For feeding the blast with liquid to be blown to a spray the devices heretofore used in atomizers for surgical or other purposes are not well adapted to field-poisoning. The principle of blast-suction so commonly employed in them will not lift from large, very deep reservoirs and feed to the blast the supply of liquid required in large machines; while those which use blast pressure are so constructed as to squirt the liquid of the reservoir upward in opposition to gravity, and to raise it thus out of a large, deep reservoir requires more exhaustion of force to operate the bellows than economy will warrant. And the same will be true when air-pumps are used as described farther on. A much better plan is that in which the fluid gravitates into an automatic feeder or directly into the blast passage, with or without the assistance of blast-pressure or blast-suction. Thus it will be seen that the blast-pipe to be fed with liquid should pass below the level of the liquid, and with this limitation may have any position that is convenient. If it pass outside the reservoir one or more conveyor-tubes to or from the blast must be added to communicate with the reservoir. To avoid some complication and secure greater compactness, with better working, the blast-tube is preferably passed through or against the lower part of the reservoir, from which one or more passages gives the liquid exit into the blast-tube. The quantity to be fed out must be gauged by the size of the outlet or outlets, which may be formed of permanent size, or can be increased, diminished, or closed at will by any adjustable partial or complete shut-

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off arrangement. Before the blast has reached the outlet just mentioned a part of it should be passed above the liquid and in the tight reservoir (by way of a tube, or by direct egress from the blast-tube when the latter is in or against the reservoir), to rise above the liquid (through it or through a tube), to give a pneumatic pressure upon the liquid, and so assist gravity in forcing a constant jet therefrom into the blast.

When planning the construction of apparatus in which blast-pressure through one passage is to be used to eject the liquid through another into the blast the following principle should be observed: In order that the blast-pressure through the one passage shall be against the liquid more strongly than through the other passage, to squirt or help squirt the liquid from the latter, thus to feed the liquid to the blast, the blast-tube is constructed with greater capacity opposite and beyond the ejection passage into itself, and this may also be accomplished by making any partial obstruction of the blast, by crook or otherwise, in that part of the main passage which is between the two reservoir communications.

When it is desired the blast and liquid can be conducted together through very long tubes, and, by the chambered forks or angles, may be equally divided, to supply one or more reverberatory jets at a distance.

If the blast-pipe ends close to where the liquid feeds it, the latter will be blown in a fair spray; but if the liquid must pass with it in the pipe for a considerable distance, and especially if there be any crookedness in the course, the liquid becomes more or less condensed, and no satisfactory spray results without adding a special device for reatomizing it, and this is best done by attaching the eddy-chamber nozzles, such as have been already recommended for squirting sprays, and others similar, but provided with different outlets. In any case, even if no conveyor-tubes are necessary, the best atomized spray is obtained by the employment of the reverberatory jets, which, like the feeding arrangement described, can be constructed with capacity for larger volumes of liquid and of spray than the old-fashioned atomizing principle will produce. The next best thing to the simplest reverberatory jets for this purpose is also new. It is the whistle jet, which differs from the eddy jet in having its outlets peripheral, and preferably close to the outside of the inlet, being the same plan of nozzle as that shown in plate XXXII, Fig. 6, and described above, but preferably with some modifications. One distinctive characteristic of this is that it receives a blast across the *inner* face of the outlet hole. As will be seen, it makes one and the same stream return back to intercept and atomize itself. But while the foregoing styles seem preferable for agitation-chambers for these purposes, under certain limitations the number and location of the inlets may be altered, and the spray outlet or outlets may have any other position, such that the current must, in order to find exit, be given a suddenly tortuous or zigzag course by and in the chamber, while the form of the outlet may be cut in various shapes with good

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effect, and the chamber may have only plane and angular conformation, or can possess certain irregularly or regularly curved contours.

An allied and very simple form of atomizer-nozzle, which is only of value with blasts, consists of a blast-tube with its discharge end closed completely, and having one or two discharges through its side at a short distance from the closed end, as shown in Plate XXXI, Fig. 6. The air in the short cavity of the tube between the outlet and the closed end acts as an elastic cushion, and there takes place a rebounding and rotary action of the blast, whence atomizing results. With the agitation-chambers the blast dashes, spreads, and grinds the poison against the inner surface of the chamber. Thus they disintegrate, mix, and diffuse any lumpy accumulations of powder poison or masses of liquid that enter them, and the greater the blast force the finer will the powder or spray be discharged.

This introduction of agitation-chambers in atomizers for diffusing or mixing the materials just before they are discharged, and emitting them thus mixed and in a state of intense agitation, is due to myself, and I make them in many different shapes. The activity within is of a reverberatory character, generally arising by internal deflection, causing vibration, collision, intercepting, or whirling of currents. The spray may be discharged from the chamber in any direction or at any angle desired, and an atomized spray at right angles from the end of a pipe is just what has been needed to make both practical and economic the process of poisoning the nether surfaces of crops.

Prior to these the atomizing was done on the principle of a blast blowing the emitting liquid immediately from the discharge of a pipe supplying the liquid and thereby producing atomized spray. The terminal portions of the blast-pipe and the liquid supply-pipe stand approaching each other at an angle, or either may surround the other. Although an immense number of atomizers for surgical and other purposes have been patented, the above principle characterizes them all. In patent No. 173194 Mr. W. V. Wallace claimed a device for catching and returning to a receptacle the drip, which flows in considerable amount as waste from these atomizers.

Mr. Thomas Woodason, of Chicago, Ill., is manufacturing an ordinary atomizer represented in Plate XXXII, Fig. 4. The can, *p*, contains the poison. The bellows, *v*, has its spout soldered to the top of the can, and discharges across the end of the tube, *p*. As a result the rarefication produced in the ascending tube enables the atmospheric pressure in the can to cause the liquid to rise through the tube, and from its top the atomized spray is blown. This is one of the simplest atomizers to construct, and it makes a fair spray. It is a small hand instrument to produce a single spray in directions not deviating greatly from the horizontal. Its feeding principle by blast suction will not work satisfactorily except for a very shallow body of liquid; hence the reservoir is necessarily small, and must be filled very often. The first part of the blast is wasted in producing a vacuity, and some poison is lost as drip.

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A large reservoir of liquid on the spout of a hand bellows would be too unwieldy even were it practicable in atomizers made on this principle. To remedy this in such apparatuses and prevent waste by dripping I have added an automatic supply by way of a small tube leading from a larger reservoir carried higher, as between the shoulders, upon the back, or upon one of the handles of the bellows, or otherwise, together with other features, all of which may be better explained by the figures. As seen in Plate XXXII, Fig. 5, bellows, *v*, has a long blast-tube, *i*, opening at *e* into the chamber, *p*. This also produces a pneumatic pressure upon the liquid in the can, *p*. A poison-inlet, *l*, connects with a rubber tube from a larger and more elevated reservoir, not shown in the figure. A diagonal tube, *xy*, has its lower part open in the proximal lower angle, *x*, of the can, *p*, while its upper end opens at a larger orifice, *y*, through the upper face of the can, and preferably near its distal side. This instrument is designed to be held with the pipe, *i*, directed downwards to carry the can, *p*, beneath the plants sprayed. The liquid horizon will then be at the lower extremity of the inlet-tube, *l*. Each blast depresses the liquid, causing some to rise up through the tube, *x y*, and be sprayed upward by the ascending blast at *s*. At the same time a small volume of the air is forced to enter the tube, *l*, and ascend into the larger reservoir, to displace water enough to restore its level up to the lower extremity of the tube, closing its orifice so that no more air can enter, and hence no more liquid can descend. Thus the very small can, *p*, is fed automatically, itself being of a very wieldy size and serving rather as a nozzle than as a reservoir. When a large supply of poison is not needed the tube, *l*, may be corked tight and the can, *p*, is filled through the hole, *y* or *l*, preferably by immersing the whole can in a vessel of poison so the latter may enter at either of those orifices.

The liquid is drawn in quickly by opening the bellows while closing its suction hole by the thumb or hand. In this device blast-pressure rather than blast suction feeds the liquid out, and the blast-discharge is taken preferably from a facial orifice, whence it surrounds the outlet of the liquid.

The foregoing device is quite practical, and there are no difficult points in the construction or adjustment of its parts. But the ordinary mechanic finds it more difficult to construct the following machines accurately in all their proportions, although they are no more complex than those already noticed, over which they possess mechanical advantages, in their operation and application, giving a preference. The principles which I have introduced in these render possible the construction of practical compound machines for delivering two or more blast-sprays from a single blower and a single feeder. This, also, is accomplished without complexity and at moderate cost. The following examples should be considered here. The simple hand apparatus in Plate XXXI, Figs. 6, 7, and 8, will be described first. The internal anatomy of the feeder

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is shown in Fig. 7, where *p* is the feeder-can containing the liquid poison and *y* is the blast-pipe. This is united with a screw cap or plug which unscrews to separate and open the can. From the blast-pipe there projects a small tube, *x–y*, in the can and opening near the basal apex, *x*. This is the feeding-tube to conduct the liquid up into the blast. Its lower end, *x*, is at the bottom of the liquid and will remain so whether the side, *a*, or the side, *n*, be down, wherefore the blast-pipe may be directed considerably downward or upward or horizontally without bringing this end above the liquid. The opening of this end is preferably quite small, but even for single sprays of good size it need not be small enough to clog, with ordinary care to keep the liquid free from rubbish. But when in careless hands, or dirty liquid must be engaged, clogging may occur. In such cases the can is removed, and a wire forced up through the small passage to clear it. When no can-screw is employed, and the pipes are inseparably joined to the can, a means for clearing the feed-pipe is provided by having its lower end extend through the base of the can where it is plugged, while a lateral perforation through it just inside of the can admits the liquid. Then the end may be opened to pass up the wire probe. Also, the feed-hole into the side of the tube may be formed as a slot, which can be more or less closed by adjusting the plug slightly, and thus the liquid supply can be increased or diminished or shut off. The plug may shut off the inlet either by deeper insertion or by rotation upon the axis. The upper end of the feed-pipe is generally cut diagonally, and this diagonal part projects into the blast with its slope to the leeward. There are certain delicate advantageous peculiarities of form for this orifice which need not be detailed here. Near the feed-pipe perforations are made to allow blast-pressure to be exerted upon the liquid to force it up in the feeder-tube. Thus the feeding principles are similar to those in the device just previously described. Also the uses of the automatic supply-tube, *l*, are the sameas were given above. But in the machine before us there is not an immediate spray-discharge; the blast and the liquid fed to it are conducted onward by an extension-pipe. If this be very short, as at *j–s*, in Fig. 8, and the mouth-piece, *o*, be blown-into strongly, a direct spray will be emitted at *s*; but the longer this extension-pipe and the more roughness and crooks it possesses the more will the spray become condensed against the side of the pipe, or separated from the blast to flow in the pipe; wherefore at some distance its valuable qualities are lost. But by these means the liquid and the blast are both conducted in one and the same pipe, to be *reatomized* by the terminal nozzle or nozzles. Instead of the oral blow-pipe of Fig. 8 a bellows may be attached on the one end and a long extension-pipe on the other. This arrangement appears in Fig. 6, where like letters indicate how the parts correspond to those of the figures already just described.

The pipe terminates in the simplest form of reverberatory nozzles, described above. Certain of these give spray at an angle from the pipe,

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while others emit the spray in the direction of the axis of the pipe. The pipe, *i*, should be preferably so extended as to carry its jet, *s*, beneath the plants. The pipe, *l*, may be inserted in the wall of the can at any point above the desired level of the liquid which closes the lower end of the pipe so that air cannot ascend to the large, tight reservoir. Hence, the liquid can rise no higher than to close its lower orifice. As soon as the liquid is lowered so much that air can enter and pass to the upper reservoir liquid enough will descend to close the entrance again. With this arrangement the feeding of the blast goes on, and the small can does not have to be filled. This supply-tube may have a stopper, or be connected with an automatic supply from a larger, higher reservoir, as previously explained. It may be seen that whether the angle, *x*, or the side, *a*, or the side, *n*, be downward the passages at the corner, *y*, will always be above the liquid, so that when the instrument is in operation it can be directed downward or upward, as well as horizontally. By this machine the blast is fed with certainty and strongly. Since there is no immediate communication of the surrounding atmosphere with the reservoir, *p*, the liquid is not raised in the pipe, *x–y*, by the ordinary process of atmospheric pressure, but the blast-pressure, which is more powerful, is applied. Here it should be noticed that the blast also bears down upon the liquid in the tube, *x–y*, as well as on that in the chamber, and were its force equal in both these places the water would not rise, for the elevation must be due to the reservoir pressure exceeding that in the feed-tube. To secure this condition the main blast between the incurrent and excurrent orifices, at *y*, should be partially obstructed, and this can be accomplished in various ways, here by one side of the tube, *x–y*, projecting into the main passage. It can also be done by a crook, or by having the main passage made larger beyond the pressure-hole. It should be noticed that with this device, even when no valve is used between it and the bellows, the liquid will not flow back into the bellows past the pressure-inlet, for there it naturally enters again into the chamber.

An important feature of this device depends on the fact that it may be turned upside down, and so works with less effort, while gravitation causes the liquid to feed into the blast uninterruptedly by way of what was in the other case the distal pressure-hole, and the tube, *x–y*, or a hole preceding, it now serves to pass the blast-pressure above the liquid.

An apparatus having these characteristics, also adapted to poisoning under-surfaces and others, is shown by a plan view in Plate XXXII, Fig. 6. The bellows, *v*, has a very long blast-pipe, *i*, with an angular discharging-nozzle, *s*, which can be turned on the pipe, *i*. At the base of the pipe, *i*, is a crook, recess, valve, or partial septum, to prevent the poison from entering the bellows. The reservoir, *p*, has a supply entrance, *l*, which may be closed, or can have a pipe connection as an automatic supply from a higher reservoir, carried by the operator or a

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horse or otherwise. The chamber, *p*, communicates with the main blast by the pressure-tube, *x–y*, and the poison-passage. When desired, this aperture has an adjustable shut-off to regulate or stop the flow therefrom. The handle has an incurrent air-valve.

Either of these apparatuses may have, instead of a single jet, two or more jets on pipe-branches, and thus were made compound machines involving the same principles. The systems of branching tubes [Pl. XLIX and XLVI] and the conveyances in these machines combine also with others, and also the liquid-feeding reservoir made on the plan just described may be substituted in place of the powder-can in the apparatuses presented above and in Plate XXXIII.

On the other hand, in making very simple atomizers on the above plans the extension-pipe, *i*, may be omitted, and the spray-nozzle can be formed as a compartment of the reservoir, or be attached thereto by a short neck.

"A portable spray machine (Plate XXX, Fig. 4) was made a few years since by Mr. W. P. Peck, of West Grove, Pa., consisting of a tank strapped knapsack-fashion on the shoulders, and connected by rubber tubes with a pair of bellows, buckled to the waist, turned by a crank, and connected with a movable nozzle. The tank holds three gallons, and there is a simple device at the bottom, which, by the motion of walking, keeps the liquid in agitation and prevents the poison from settling. The liquid issues in a fine spray and with considerable force."

Mr. W. V. Wallace, of Boston, Mass., patented in 1876 (No. 185603) an elastic bulb, discharging a blast in the spout of a watering-pot to blow a spray therefrom, which seems to cover the spraying principle of the Peck machine.

RECIPROCATING OR PISTONED BLOWERS.

[Plate XXXV.]

(*a, for powder; b, for liquid.*)

The piston-pumps in Plate XXXV, Figs. 1 and 2, and described below, or other air-pumps, may answer as blast producers for blowing powder or fumes, and for atomizing liquids. For these purposes the cylinder of the pump should be preferably larger than when it is to be used only for compression. With such blast generators powder feeders or atomizers of the kind already described for use with bellows can be combined with or without distributing pipes and nozzles as desired for simple or compound machines. These same appurtenances were planned for blowers of any kind, but the air-pump shown in Plate XXXV, Fig. 1, was invented and used by myself in such combination and subserves the purposes very well. The pump discharges through its hollow piston-rod, and this is easily coupled to the blast-pipe of the feeding and distributing apparatus.

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. The blast-pipe and hollow piston-rod, *s*, bears the piston head, *a*, in the cylinder, *v*. A handle, *u*, is formed on the pipe, and others, *h*, on the cylinder. The ends, *h' h''*, of the cylinder should be convex or concave to give stiffness to the sheet metal of which they in this instance are formed. Also at the end, *h'*, the piston-head, *a*, is prevented by the convexity from approaching too close to the piston rod passage or its packing at the neck of the cylinder, thus tending to keep the piston parallel with the cylinder or prevent its rocking in the same. The sides of the cylinder are preferably double, in order that bruises of the outer wall may not affect the smoothness of the inner wall, and for other purposes. The valves are of the kind described for my bellows heads above. These incurrent valves are made near the ends of the cylinder, at *oo*, and they act in alternation.

The piston-head has flexible margins, which hug the cylinder loosely, but more tightly under the air pressure. To make these margins a belt of flexible material, broader than the head, *a*, has its center shrunk by a tight wire into a groove in the circumference of the head, or a pair of flexible cups may be used joined base to base. The head is free to slide on the piston-rod for a very short space between the two annular flanges or bearings, which may be alternately applied to their packings on the head. These packings could be free or attached to the flanges. It may be observed that when the head is against the one flange there is left open an entrance between the head and the other flange as an inlet from one end of the cylinder into the piston-rod and blast passage; also that when the head is against the other flange said entrance is shut off from that end of the cylinder, and there is uncovered another opening at the opposite side of the head as an outlet from the other end of the cylinder into the hollow piston and blast-pipe. When either the cylinder or the piston rod is moved reciprocatingly with reference to the other the pipe inlets are alternately opened and closed, the slip-head of the piston acting as a valve in opposition to the end valves, so that both strokes of the piston or cylinder discharge the blast, making it constant. A piston-rod with a single inlet may be used, so placed that the slip causes it to appear first on one side of the head and then on the other. The pump is calculated to be worked by the two hands, one hand at *u*, holding the piston or blast-pipe, while the other hand at *h* moves the cylinder, *v*, back and forth. Where this sort of pump is combined in machines any method of giving reciprocating motion in such machines will answer for operating it.

In this connection it may be well to state that Mr. Henry Hunphreville, of Mountville, Pa., patented in 1880, 1881, and 1882, (No. 251886), some air-pumps for spray-dampeners, the latter being very simple, but not specially adapted for spraying upon plants, since only the old-fashioned atomizing principle is used, and not in such shape as to discharge upward. There are many air-pumps in the market, but such as are specially needed for field use have not yet appeared in the trade. That

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shown in Plate XXXV, Fig. 2, as manufactured by Messrs. Rumsey & Co., of Seneca Falls, N. Y., may be given as typical of those most commonly on sale. It is susceptible of attachment to the frame of any vehicle or machine. The cylinder, *c*, lever-fulcrum and piston-rod guide, *o*, are attached by lugs to the board, *b*. The brake, *i l*, has a link-shaped pitman, *i o*, communicating its motion to the piston-rod, *r*. At *s* is the discharge, which may be coupled by hose or otherwise, with a blast feeder and its distributing accessories for dispersing poison.

Air-pumps for other purposes are noticed below.

D.—GENERATOR BLOWERS.

[Plate XXXVII.]

The feeding, atomizing, and distributing devices already described in other kinds of blowers may be operated by steam blasts, and for this purpose can be combined with any ordinary generator that will supply volume enough of steam and serve therewith as a force-medium. Many special examples of such combinations might be described, but only one will be noticed as appearing in the description below.

"*The Steinmann Vaporizer.*—This was invented by Mr. Charles Steinmann, of Napoleonville, La. (patent No. 74165, February 4, 1868). Its character may be thus briefly given: Steam is raised by a transportable steam-boiler, and issues from a series of jet-pipes or nipples. At the same time some cheap oil, as kerosene, lard, or cotton-seed oil, is made to drip from a reservoir over the orifices from which the steam escapes. The oil is thus vaporized and envelops the rows of plants between which the machine is to be drawn. The inventor claims that the vapor kills the worms without injuring the plant, and that one application will protect the field for the rest of the season, and that his invention 'upon its general use will finally exterminate every tribe of insect,' &c. It is hardly necessary to say that the two latter claims are utopian and extravagant.

"The following is a description of this machine in the inventor's own words; the Plate XXXVII, Fig. 1, being a side elevation, and Fig. 2, a rear end view of the machine:

"A represents the receiver or reservoir to contain the oil, and B a funnel for supplying the boiler with water, and which connects directly with a heater, E, that is placed on top of the boiler, instead of with the boiler proper, in which heater a supply of water is always kept, to be heated by the radiation of heat from that part of the boiler or shell of the boiler on which it rests. The interior of the heater is connected with the interior of the boiler, F, by two pipes, H and O, which are each provided with a stop-cock. By this mode of connection, the water in the heater can be retained or driven into the boiler at pleasure, it being only necessary to keep the cocks closed to retain it, or to open them to force the water into the boiler. The latter result is accomplished by the pressure of the steam through pipe, H, the water going into the boiler through pipe, O. Whenever the water is thrown out of the heater into the boiler, the former should be refilled through the funnel, B, the stop-cock, in the short pipe, R, to which it is attached, being opened to allow the water to enter. On

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top of the boiler, at some point between its rear end and the heater, E, a perpendicular pipe, C, is inserted into it, which pipe should be long enough to carry its upper end to a height somewhat above the tallest cotton-plants. The pipe, C, is provided with a stop-cock, D, and connects at its upper extremity with a cross-pipe, M, of the form as shown at Fig. 2, and to approach very near the ground at both its ends. In that portion of the pipe, M, that is horizontal are two stop-cocks, one upon either side of the point of connection with pipe, C, which serves the purpose of stopping the issue of steam either entirely, or upon one side only of the machine. At a point near and below the flexures or elbows of the pipe, M, at which it turns towards the ground, on both sides of the machine, and from this point down to the two extremities of the said pipe, at short intervals, are inserted small short pipes, *a*, which, diminishing in size to their extremities, where they come very nearly to a point, serve as vents or jets for the escaping steam when the machine is in operation. Placed alongside the pipe, M, in front of it, and in contact with it everywhere, excepting only for a little space near its top part, where it bends forward, as shown at Fig. 1, is another pipe, K, exactly corresponding with pipe, M, in size and shape, and provided with the same number of precisely similar jet-pipes, *a*, that are so placed as to be exactly over the corresponding jets in pipe, M, that is to say, at their extremities, and in the closest possible contact therewith. The object of this is to insure the dripping of the oil over the orifices from which the steam escapes. Over the center of the upper and horizontal section of pipe, K, and connecting therewith by a short pipe, *d*, is placed the reservoir A for oil. Stop-cocks in the pipe, K, near to and upon each side of the pipe, *d*, prevent a flow of oil down either end of said pipe, K, or permit it to flow into both or only one end, as occasion may require, at the pleasure of the operator. A platform in front of the boiler or furnace is provided on which a supply of fuel may be carried, a light railing or lattice-guard on the sides of the platform protecting it. A driver's seat, P, is placed on this platform, under which a vessel of oil may be carried, as well as other things needed in the operation of the machine. This invention may be of any dimensions, to be drawn by one or more horses."

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CHAPTER XII.

MACHINERY AND DEVICES FOR THE DESTRUCTION OF THE WORM.—Continued.

IV.—PNEUMATIC COMPRESSION SQUIRTERS.

Various devices can be engaged to produce air, gas, or vapor pressure upon the liquid in a tight reservoir to eject the liquid contained, and such pneumatic compression ejectors may be used instead of force-pumps, with the various distributers of poison to constitute insecticide machines. These I have classified under four subsections, viz:

1. Expansion generators. 2. Rotary force blasts. 3. Oscillating pneumatic bellows. 4. Pneumatic reciprocating pumps.

EXPANSION GENERATORS OF GAS, HOT-AIR, FUME, OR VAPOR PRESSURE, AS INSECTICIDE SQUIRTERS.

[Plate XXXV.]

The expansile power from the generation of these states of matter is utilized by substituting a generator for the force-pump or bellows of the apparatuses elsewhere described. In such combinations I have found the gas-pressure process to work very satisfactorily. By the methods set forth it will be one of the easiest, most economic, and most effectual ways of applying insecticides.

Gas-pressure generators have been used with great success in small fire-extinguishers. The employment of these or similarly constructed apparatuses has been suggested for squirting poison on crops. The expense of such machines and their chemicals has proved too great, and there is in their operation a great waste of the gas, and of the chemicals which does the crop no good and which can be avoided by a different method according to which the gas is generated and its pressure applied for squirting poison in a more economic manner. By fire-extinguishers the chemicals and the gas itself are partly squirted away with the liquid. These are not mixed with the liquid in the generator which my experiments led me to prefer. The gas is passed in on top of the poison, pressing it downward in the barrel or reservoir from the base of which it squirts out through a simple or branched pipe or pipes and their terminal nozzles.

Carbonic anhydride is the most cheaply and easily made and used. This is best prepared by the action of sulphuric acid on bicarbonate of soda. Carbonates of lime, as marble dust, &c., and vinegar or other acids

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may be used, but sulphuric acid and the bicarbonates are cheaper and better. The sulphuric acid retails at about 5 cents per pint; wholesale, 2½ cents. Marble dust, so extensively used in preparing soda water, is the cheapest carbonate, costing only 1 cent per pound, but is not economical in these small generators in view of its bulk and slowness of action. The bicarbonate of soda, which works best, sells in quantities at 4 cents per pound. After decomposing it the residue is sodic sulphate or Glauber's salts, which has a little value (about 1 cent per pound) and may be saved. My experiments indicate that 1½ pounds sulphuric acid, $0.07, to 2 pounds bicarbonate of soda, $0.08, total, $0.15, mixed, will squirt 40 gallons 6 feet high over 1 acre at a cost of 15 cents. Forty gallons is the amount of water which has heretofore been applied to the acre; but I have shown that an acre may be poisoned by one-third this quantity with my eddy jets, which reduces the above cost of chemicals and labor to about 5 cents per acre. This includes the labor since the driver can easily attend to the generator. Where the reservoir is high, and when the cotton is of average height or lower, a part of this chemical force and expense will not be necessary. Also the acid will cost only one-half the above price if bought at wholesale rates, as it can be where several pounds are needed which almost invariably is the case on ordinary plantations and large ones. Thus the gas-pressure process is made economic, and indeed very cheap. The ease of this method also strongly commends it. The management of the generator involves almost no labor at all. It can be attended to by the driver without stopping and no assistance is needed. The appliances designated below settle the question of practicability.

Since ordinary tight reservoirs with branching pipes and nozzles, as have been already described, can be used in this process for distributing the liquid it will be in order at once to give special attention to the apparatus and materials for generating the pressure.

The generator need not be expensive, and for the slight pressure required in sprinkling the under surfaces of plants great strength or weight is not necessary, while a large sheet metal can or stout barrel serves as a reservoir. Beer, wine, whisky, or kerosene barrels answer. The generator consists of two chambers, one for the acid, the other for the substance it is to act upon, and so arranged that by tipping one or both of the chambers, or by adjusting a shut-off between them, one of the materials can be fed into the other in any proportion or at any moment desired, to control the pressure at will. These chambers may be connected end to end, side by side, or one partially or totally inside the other, or otherwise. In small generators they ought to carry at least enough chemicals to eject forty gallons; that for pure or diluted acid having a capacity for one quart or two pounds or more, and the other for the carbonate, or carbonate and water, to hold two or three quarts, since it is better to have the carbonate in excess and to add enough water to wet it thoroughly. A simple plan is to put the acid in an un-

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corked bottle, or other vessel, contained in a larger tight jar or vessel with the bicarbonate between the two, so that by tipping the whole more or less of the acid is turned into the carbonate.

Plate XXXV, Fig. 3, shows a plan for generators of this kind, in which the acid bottle, *a*, in the interior is surrounded by the bicarbonate, *b*, in an ordinary two-quart fruit jar with a lead screw-cap perforated by the outlet spout, *e*, for exit of the gas which is conducted through the hose, *h*, into the top of the barrel or reservoir containing the poison. By having the two chambers thus compactly conjoined the apparatus is simple and handy as a small generator.

But there are certain advantages in having the two chambers separate and connected by means of a flexible tube, and this construction is surely one often to be preferred for large generators, when a cheap home-made apparatus is wished. The short piece of flexible tubing should be of good rubber, and although the acid corrodes it somewhat, it will endure for one season at least, when a new piece can be substituted at a trifling cost. Fig. 4 in plate XXXV shows this apparatus. The jar, *t*, contains the bicarbonate, *b*. Its screw-cap, *t*, is made of lead. From this is a lead outlet tube, *e*, coupled to the reservoir, *r*, of poison, *p*. The cap is also perforated by the lead tube, *j*, coupled to the hose, *h*, leading from the acid-bottle, *a*. The latter is to be elevated and inclined by one hand to pour the acid into the bicarbonate. Thus at intervals a few minutes apart a little acid is added. When the driver sees that the spray is not going as high as desired he applies a little splash more of the acid to increase the pressure. This is one of the easiest ways in the world for spraying poison. It is really more pleasure than labor. In the generator, *t b*, considerable heat is evolved and it will often become too hot to be handled. On this account it had better be so fixed that it need not be touched and its temperature may be kept down by keeping it wet. It is easily hauled or carried in a bucket containing some water with a little soft packing material beneath and around it. The less the amount of water mixed with the bicarbonate, the less heat will be generated, but enough water should be employed to wet the soda, otherwise the sodic sulphate formed by the chemical process arises as a crust and keeps the acid from reaching the remainder of the bicarbonate, thus retarding or stopping the generation of gas.

These pressure generators are cheap, of simple construction, easily understood and used by any one, while the action is under perfect control, and danger from bursting does not exist. There is no need of putting in too much acid and running the pressure too high.

The rubber gum hose is stout enough to squirt the poison as high as needed, but the gum will give way and burst before a pressure if any danger is attained. Thus there is nothing to fear from explosions.

The acid is a very injurious poison and should be handled with great discretion; but the bicarbonate used with it is always at hand as a sure antidote, and on the ground of its being dangerous the acid is no more

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injurious or objectionable than Paris green, other arsenical poisons, hellebore, &c., which are in common use. The sulphuric acid should be labeled—

In case it gets upon clothing it burns a hole through, and should be treated quickly with bicarbonate of soda, hartshorn, or soap. When upon the skin the same may be applied or it can be washed off quickly by water, but if by accident it be drunk, *avoid taking water*, but swallow quickly either raw eggs, any albuminous substances, carbonate of magnesia, of calcium, of potassium, or of soda; also, chalk, soap, or whiting in milk may answer; but finally in all cases *oil* should be taken in full dose. The acid ought never to be left in a vessel such as a child or grown person might suppose to contain water or some beverage; also a card bearing all the above instructions ought to be given with each vessel containing the acid, and be always carried with, but not in contact with, the vessel or the acid which would destroy it. The materials for generators are preferably glass or lead, substances which are not impaired by the acid. Glass is liable to breakage, but very stout glass may be used and it is more satisfactory to be able to see the interior readily to observe the action and quantities of the substances within, and especially the amount of acid being poured. To render the glass less likely to break, each vessel is protected by a frame to deaden the impact of any blows it may receive. The vessel is guarded as lanterns are by a metallic frame, or as coal-oil cans are now made of glass with corrugated sheet-metal cages, as carboys are by a net-work of cordage, as demijohns are by wicker-work, though preferably of a more open character. But simple wooden encasements are easily made of end-blocks connected by longitudinal slats, as in Plate XXXV, Fig. 4*a*, or otherwise. When either vessel or chamber is made of metal it is preferably a lead cylinder, tube, bottle, or can. Although any metallic acid receptacle is necessarily of lead, that for the generator is kept alkaline by the excess of bicarbonate in it, so it corrodes far less and endures a long time of whatever metal it be composed. There are several ways in which the apparatus is made of metal, and some of these must be noticed briefly. A good metallic chamber as acid bottle or generator, or both, is made of a cylinder or section of pipe constructed to open at one or both ends by a plug or cap. A screw-cap is generally preferable. Beneath it a packing ring or plate may be clamped. This, if iron be used, will keep the acid from eating the screw-thread and the other thick parts of the iron endure a long time. The cap is perforated by a tube, or tubes, to communicate with the other vessel or vessels.

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Several years ago while teaching chemistry I made a gas generator on this plan, and it gave perfect satisfaction. Where other gases are used, such as are generated by heat, such a metal generator is very essential. The generator chamber needs to be cleared out or charged occasionally, and this is not easily accomplished, unless its end opens entirely by a removable plug or cap. The metal chamber can be roughly jarred or gouged out with no resultant breakage. The acid chamber ought preferably to have its neck or mouth provided with a metallic lead cock or other secure non-corrosible shut-off device.

ROTARY FORCE-BLAST, COMPRESSION EJECTORS.

The rotary force blast blowers have not yet been utilized in insecticide machines.

OSCILLATING BELLOWS, PNEUMATIC COMPRESSION EJECTORS.

[Plate XXXV.]

The bellows recommended for blowing powder and atomizing liquids can also be used for producing air-pressure in a tight reservoir to eject the liquid contained; and in this way may serve as a substitute for a force-pump or gas generator. The bellows should be small and very strong, that an unusual amount of power may be applied to do this work. In order to avoid resuction of the blast back into the bellows and to be able to produce a constant condensation in the reservoir an excurrent valve from the bellows must be interposed between it and the reservoir. By such means parties having a bellows for atomizing can also apply it as a machine to squirt liquid for poisoning or irrigating, &c., and its notice here may in some cases prevent the purchase of a force-pump when not necessary. Also experiment with such devices may show that they are preferable to pumps in some squirting machines. Since many prefer the application of dry powder in rainy weather, and of wet poison in dry weather, such parties can make a bellows answer for both methods. The bellows may be worked beneath the foot, and the weight of the operator's body can thus be used, which will be found more pleasant than the exertion of arm-power. Machines for squirting by bellows-pressure are now articles of trade, and in use chiefly for forcing beer, &c., from barrels. So far this use of the ordinary bellows only promises to be practical where small pressure will answer.

The simple process is indicated in Plate XXXV, Fig. 5. The bellows, *v*, operated by the lever, by foot, by hand, or machinery, discharges through its excurrent valve and the pipe, *k*, into the top of the barrel, *r*, whereby the air compressed in *r* forces the liquid, *p*, downward, causing its ejection through the outlet tubes, *n* or *m*–*m*. Nozzles, *ss*, may be connected to the outlet tubes in any suitable number or by any system of couplings or pipes. There are other ways of combining the bellows with the reservoir, but only one simple illustration can be given here.

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RECIPROCATING OR PISTONED, PNEUMATIC SQUIRTERS.

[Plates XXXV to XXXVII.]

In such apparatus as has just been alluded to for squirting liquid by producing air-pressure upon it, a piston air-pump may be substituted in place of the bellows or generator. Indeed, the air-pump is a most powerful machine for this work, and is preferable to ordinary oscillating bellows where high pressure is desired. On the other hand air-pumps have been more expensive. One reason for this is because their mechanical execution involves very accurate turning and fitting. But they may be made in a cheaper simplified style, available for squirting, as has already been shown in my pump, illustrated in Plate XXXV, Fig. 1, and explained on page —. That pump is operated in the position shown by seizing its side handles with both hands and thus moving the cylinder up and down. The same is also worked substitutively by machinery, by a lever, or by a single or double acting pedal. When the single-acting pedal is employed it is especially of value to use a large spiral spring inside, to cause the return stroke by its recoil.

An inverted air-pump, worked by a pedal linked to the piston-rod and having pipe connections with a barrel for forcing out beer, &c., is manufactured by the Worswick Manufacturing Company, Cleveland, Ohio, and is sold under the name "Bellows No. 2."

Also an apparatus available for similar purposes is manufactured by Mr. H. Weindel, of 405 North Fourth street, Philadelphia.

Air-pumps that may be used in combination with squirting apparatuses, and worked by hand-lever or crank, are manufactured by Messrs. Rumsey & Co., of Seneca Falls, N. Y., and Messrs W. & B. Douglas, of Middletown, Conn. They are strong and show good workmanship. One of the simplest and cheapest of these is that illustrated in Plate XXXV, Fig. 2, and described above. Its spout, *s*, and the barrel, *r*, should be connected to the pipe, *k*.

An interesting machine of this class is that patented (No. 200376) February 19, 1878, by Mr. W. J. Daughtrey, of Selma, Ala. Concerning it and the matter quoted below from Bulletin No. 3, the following should be added. His patent papers mark an important epoch in the history of the methods of poisoning the Cotton Worm, since they embody the first presentation published or on record of the idea that poison should be applied to the under surfaces of the cotton foliage, and in the finest spray possible. These ideas are there set forth in the strongest manner by Mr. Daughtrey in the following language:

"As the lower sides of the plant-leaves are generally infested by the vermin, the nozzles are so arranged as to force their fine sprays upward, but they may with little labor be set or arranged to deliver their sprays almost in any direction desirable. As the lower sides of the leaves are more susceptible of retaining moisture, my method of forcing the poisonous spray upward will suit the majority of cases, as the purpose is to keep the poison in direct contact with the food of the vermin, and so insure the destruction of the latter. * * * I am aware that sprinklers have been made and used for sprinkling plants, but in such cases the shower of drops is too heavy to be retained by the plants, and consequently the greater part of the shower glides off the

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leaves and is deposited in the ground which is thereby poisoned and rendered unfit for the growth of the plants, while the waste of labor and material can hardly be compensated by the benefit of such a mode. Fine showers without artificial pressure have also been adopted; but by this mode the small drops have not enough power to penetrate the minute fur or other protective coverings or coatings of the under side of the leaves, and consequently accumulate and form drops too large to be sustained by the leaves, and so fall to the ground. Such fine showers have been created by means of fine orifices which are easily obstructed, and deliver but a very small quantity of liquid. The openings, *w*, in my improved nozzle, N, are large in comparison with the aforesaid orifices and deliver a great quantity of liquid, so that the machine may be moved at the usual gait of the team without failure of the necessary supply. The spray produced by the two inclined streams meeting outside of the nozzle, N, is at once copious, powerful, and extremely fine, the latter especially, because the small drops created by the concussion of the two streams spread in every direction, while in a small single orifice they propel one another in only one line and in close succession."

No one ever stated or demonstrated the modern true theory of treatment for the Cotton Worm more fully and clearly than did Mr. Daughtrey, its originator. Indeed, no advance whatever was made in this particular direction of spraying from beneath until after I was employed by Professor Riley on the United States Entomological Commission. The problem of thus spraying from below with simpler and more satisfactory methods was one that he had at heart and with which I was charged, and have labored at not only while on the staff of the Commission but subsequently during my leisure time and vacation while acting professor of entomology and invertebrate zoölogy at Cornell University. In fact, the more compound machines described in parts of this report were invented and built while I was in Ithaca and during which time, though the cost of material and construction was paid for by the commission, I received no pay.

By the results as exemplified in this report it is shown, contrary to Mr. Daughtrey's recorded views: (1) That the largest discharge-outlet for the finest spray is attained otherwise than by the two converging jets; (2) that instead of two descending hooked pipes, or one carried twice, one in each interspace between the rows is preferable and to use descending Y-forks and one-fourth as many or one with two sprays in each alternate space will answer; (3) that whether the converging jet outlets or any reverbratory chamber outlet or outlets for the jets be used, the opening is best made laterally through the wall of the tube and not directly from its end, but most preferably from the wall of a reverbratory cavity, or from the side of the inlet thereto. His machine also introduces in insect destroyers a new method of keeping the poison mixed with the water, expressed as follows:

"In leaving the openings, *p*, the air makes its way up through the water in the barrel, and produces a continuous and powerful agitation, whereby the water is thoroughly combined with its poisonous admixtures."

Mr. Daughtrey has shown much ingenuity and mechanical skill in the machine which he invented, to embody his ideas. He had developed the right objects in his mind, but introduced in his machine complica-

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tion of structure, expensiveness, and also some other features which have prevented it from coming into the market. It is an early attempt to introduce air-pumps and air-pressure in cotton-worm destroyers.

A pair of air-pumps are used, but nothing new is claimed for their construction. The arrangement for producing the spray is the old-fashioned gas jet, which was also patented in 1878 by Mr. Adolph Weber, of Detroit, Mich., as a nose-piece for spraying water. The nozzle is presented in Plate XV, Fig. 5, and its description.

The following appeared in the first edition of this work, concerning Mr. Daughtrey's invention:

"THE DAUGHTREY ATOMIZER.—There still remains one machine to be described in this connection which is highly interesting for several reasons: 1st, because it is the only one actually in use for the distributing of the liquid from below; 2d, because the construction of the pump is quite peculiar; and, 3d, because the arrangement for producing the spray is not only entirely different from any described in the foregoing pages, but also most simple. This machine was invented by Mr. William J. Daughtrey, of Selma, Ala. (patent No. 200376, February 19, 1878). The accompanying sketch (Plate XXXVI) represents it as it appears. It consists in the main of a pump, which is made self-operating by means of a pulley, and which forces air into the receiving tank and into a compression cylinder connected therewith, thus supplying the pressure necessary for the production of the spray. As will be seen from the sketch, a transverse distributing pipe is connected with a number (four in the sketch) of vertical pipes recurved at the ends, which receives the nozzles, one of which is represented in section in Plate XXXVII, Fig. 5. The nozzle. N, which is screwed onto the pipe, has a closed end, n, provided with two openings, n^1, oppositely inclined, so that the jets delivered through them meet at a point near n and deflect and disperse each other so as to form an extremely fine spray. The openings, n^1, are large enough to avoid being obstructed by small obstacles, and the spray produced by the two inclined jets is at once copious and powerful.

"The following is a more detailed description of the machine, very much in the inventor's own words, Plate XXXVII, Fig. 9, being a vertical section and Plate XXXVII, Fig. 3, a detailed view of the axle-tree, showing the parts connected therewith in section:

"In the drawings A represents the frame of a vehicle, B B the wheels, and C C^1 the two axles constituting the axletree, which have their bearings, c, fastened below the frame, A. Between the bearings, c, the axles, C C^1, are provided with shoulders, c', whereby they are prevented from parting with each other longitudinally, while a socket, c^2, at the inner end of the axle, C^1, incloses the inner end of the axle, C, and thereby prevents both axles from moving out of line. The two said axles may be coupled by means of a pin, c^3, inserted into the socket, c^2, and axle, C, but usually it is omitted, and the axles, C C^1, are allowed to revolve independently of each other. The hubs, b, of the wheels, B B, are provided with set-screws, b^1, or coupling-pins, b^2, or with both, in order to fasten them to the axles, C C^1. The use of the set-screw, b^1, and pin, b^2,

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may be dispensed with to allow the wheels to run loosely on the axle, in which case a collar, C^2, is placed on either side of the hub, *b*, with a set-screw, c^4, to keep the wheel from sliding longitudinally on its axle. The described application of the wheels, B B, to their axles serves to enable the operator to set them at any distance apart required to suit the distance apart of the rows of any field to be operated upon.

"The axle, C, is provided with a pulley, D, which, by means of a belt, drives a pulley on one end of a shaft, *e*. The shaft, *e*, runs in bearings, e^1, fastened to the top of the frame, A, and has a pulley, E^1, at the other end, which, by means of a belt, e^2, drives a pulley, F, on a shaft, *f*. The shaft, *f*, is secured in a central position to the ends of a barrel, G, by means of stuffing-boxes, and inside the barrel, G, is provided with a number of agitator-arms, f^2, for the purpose of stirring the contents of the barrel.

"The shaft, *e*, is also provided with an eccentric, H, which operates a pump, I, of ordinary construction. The supply-pipe, *i*, of the pump, I, is adapted to have a hose attached to it when water is to be pumped. The discharge-pipe, i^1, of the pump, I, passes through the barrel, G, near its bottom part, and is closed up at the end with a plug, which is removed when the pipe is to be cleared.

"Within the barrel, G, the pipe, i^1, is provided with perforations, i^2, through which either air or water, as the case may be, is forced by the pump, I, into the barrel, G. The barrel, G, is provided with an opening in its top part, through which its charge is supplied, and which, during the operation of the machine, is closed with a screw-plug, *g*. The barrel, G, communicates with an air-vessel, J, by means of a pipe, K, which has a valve or cock, R, for the purpose of stopping such communication when desired.

"The air-vessel, J, has a spring safety-valve, *j*, of common construction, which prevents the bursting of the barrel, G, and the vessel, J, by too great a pressure of air. A cock, j^1, at the bottom of the vessel, J, serves to let off water accidentally deposited there.

"From the bottom of the barrel, G, a pipe, L, conducts the charge of said barrel to a distributing-pipe, M, which is provided with a number of small pipes which are connected with the nozzles, N, already described.

"The operation of this machine is as follows: The barrel, G, is filled with the liquid either through its upper opening, or while the machine is stationary, by throwing the belts, D and e^2, off the pulleys and operating the pump by turning the shaft, *e*, by means of crank-handles. For this purpose the pump is provided with a hose, at *i*, for lifting the water from a pond or well near by. When the machine is in motion the eccentric, H, on the shaft, *e*, operates the pump, I, which forces air into the barrel, G, through the openings, i^2, of the pipe, i^1. In leaving the openings, i^2, the air makes it way up through the water in the barrel, and produces a continuous and powerful agitation, whereby the water is thoroughly combined with its poisonous admixtures. The air is led from the barrel, G, through the pipe, K, into the air-vessel, J, from which it exerts its pressure upon the surface of the water. When a sufficient pressure is obtained the stop-cock, O, is opened, whereby the water is forced into the pipes, L, M, and *m*, and thence through the nozzles, N. If the pressure of air within the barrel, G, and the air-vessel, J, becomes too great, the surplus is let off by the safety-valve, *j*, into the air. At the same time the pulley, e^2, moves the shaft, *f*, and the agitator-arms, f^2, whereby the agitation of the liquid by the air forced through the openings, i^2, is increased in force."

V.—SOLID COMPRESSION SQUIRTERS OF POISON.

In this group is included (1) Rotary force-pumps, (2) Hydraulic bellows, (3) Oscillating force-pumps, and (4) Reciprocating force-pumps.

ROTARY FORCE-PUMPS

have not yet been made cheap enough to compete with those of group No 4. On account of producing a steady or uninterrupted discharge

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and requiring no dead points in their operation they would be desirable especially in large horse-power machines, yet I think the general results of past experience with them for other purposes shows that they are less durable than the common reciprocating pistoned pumps.

HYDRAULIC BELLOWS.

The hydraulic bellows are closely related to oscillating pumps, but do not require the packings which are necessary to the latter, and there is less friction in their working. These are very simple instruments for ejecting liquids. They are really simpler than most pumps. Yet, heretofore, they have generally not proved preferable, chiefly from weakness or imperfection of construction, or from lack of durability of the materials in their composition. The faults of construction are overcome by the methods of bellows construction which I have designed and tested as set forth in another part of this work. The materials can be protectively treated, and hence the use of a small hydraulic bellows immersed in a tank or barrel, or other vessel, is a very simple and practical device for distributing liquids.

OSCILLATING FORCE-PUMPS.

The oscillating force-pump proper has for its chamber a radial segment of a cylinder. In it a radial septum or one of its radial sides is made to oscillate, or the chamber itself may oscillate when the other part is fixed. The motion is solely one of reverting partial rotation of either the piston or its chamber with reference to the other. The oscillating relation is between the piston and its encasement. This definition precludes many falsely so-called "oscillating pumps," in which the oscillation is not between the piston and its chamber. It precludes all true, straight cylinder pumps. I have tested only one pump of this group suitable for use in ejecting poison. It is patented by A. G. Brust and W. H. Douglas, of Washington, D. C. The latter gentleman is its manufacturer.

RECIPROCATING FORCE-PUMPS.

These are most conveniently considered under four headings: *a*, Hydronettes and Fountain pumps; *b*, Bucket pumps and Knapsack pumps; *c*, Aquapults, &c.; *d*, Barrel and Tank pumps.

HYDRONETTES AND FOUNTAIN PUMPS (Plates XXXVIII, XXXIX, XL, XLI, and XLIV).—Certain hand-pumps known to the trade under the above names are capable of very general application to purposes for which other special forms of pumps and syringes are used. They deserve the following notice respecting their use in the tillage of cotton, &c.:

The double-acting, hand force-pumps that discharge through a piston-tube or hollow piston-rod, which has an outside capacity equal to one-

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half the inside capacity of the outside cylinder, have been made under several patents, and some of these possess a high degree of excellence. A well-pump having tubes of these relative proportions and side outlets from the piston to the upper chamber of the cylinder, was patented by Mr. J. M. May (in No. 25207) on August 23, 1859, as "a double-acting pump." These features were afterwards embodied in the better, portable hand-pumps of the group we now are to consider more specially. The single-acting ones, having tubes with or without the proportions named, are less desirable on account of their discharge being intermittent, and they appear related to those syringes which have a hollow-piston discharge. Such a syringe, for example, was patented (No. 89362) on April 27, 1869, by Mr. H. Tyler, of Gaines, N. Y. The discharge is through a piston-tube terminating in a rose-head directed to one side, and the whole is mounted on a pair of slide-bars, by which it can be operated for applying poison in or above trees.

Mr. W. Servant, of Providence, R. I., patented (No. 107633) on September 20, 1870, a "sprinkler," shown in Plate XLIV, Fig. 1. It consists of a portable pump cylinder, *y*, having a tubular, discharging piston, *p*, working telescopically in it, all provided with suitable packings, valves, a flexible or jointed suction-tube or hose, *h*, and with interchangable solid-jet, *s*, and rose-nozzles, *r*. Ball-valves were preferably used as the base-valves of the cylinder and piston. In the figure *c* is the strainer-entrance to the suction-hose, *h*, which is coupled to the base of the cylinder, *y*, in which glides the tubular piston, *p*, bearing a handle, *m*, and substitutive solid-jet nozzle, *s*, and spray-rose, *r*. The nozzle out of use is carried on a nib as at *r*. Drawing out the piston rarifies the cylinder chamber, which atmospheric pressure fills with water to be discharged by the return stroke. Thus the pump shown throws an intermittent jet, it being only single-acting. But Mr. Servant, in his letters patent, says: "I do not intend to limit the afore-described arrangements to a single-acting pump, as they are equally applicable to a double-action pump." The general form of construction of this pump is essentially the same as that patented (No. 55022) May 22, 1866, by Mr. E. L. Staples, of Nashville, Tenn., but the latter is for insertion as a deep-well "lift-pump," while Mr. Servant seems to have first produced it in portable size with the handle upon its piston-tube and with the flexible suction-pipe having a strainer by which it can take a supply from any other pipe or from any kind of receptacle. Thereby it became a valuable pump of most general application, and has been largely manufactured in both single-acting and double-acting styles, with modifications covered by more or less subordinate patents on variations in some of its special details.

Under this patent and under others by J. A. Whitman, also of Providence, bearing date of September 20, 1870, January 8, 1878 (No. 199131), and November 1, 1881 (No. 248902), this pump has been manufactured for the trade as "*The Fountain Pump*" and "*Whitman's Fountain Pump.*"

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This brand of pump, so far as it has come to my notice, is single-acting. It has enjoyed a large sale and given satisfaction, especially for broadcast spraying upon the cotton crop.

Pumps having the same external pattern, but a double-acting, internal construction, and now sold under the name "*Hydronettes*," throw a *constant* spray or solid jet, and are hence preferable instead of the single-acting ones, which discharge by interrupted spurts. The double-acting hydronettes have for some time been manufactured by Messrs. R. T. Deakin & Co., northwest corner Twelfth a..d Buttonwood streets, Philadelphia, Pa., and by Messrs. Rumsey & Co., Seneca Falls, N. Y. The ordinary price for the "Fountain Pumps" and "Hydronettes" has been from $8 to $10.

Some double-acting *Hydronettes* devised by myself have increased the simplicity and utility of these instruments, while rendering them somewhat cheaper and more efficient. The construction is essentially the same as that presented afterward in the barrel-pump in Plate XLVI, Fig. 2, and its description; but the arrangements of the base valve and some other details are different. The removable extension-tube bearing the spray-nozzle, which is directed straight ahead or laterally, with reference to the delivery pipe, at any angle desired, is invaluable on account of the quality of the spray and because the poison is thus delivered at such a safe distance as not to endanger the operator, while its adaptability suits it for applying the spray to the under surfaces or otherwise as may be wished. This device has three interchangeable nozzles, which are free from the ordinary difficulty of clogging. The pump is also furnished with the same discharge-devices connected with the cylinder instead of with the moving piston as in Plate XL, Fig. 6. This enables the jet to be held steady, whereas the reciprocating motion of the nozzles unavoidable with the other pumps already referred to is annoying, and in poisoning under surfaces much poison is thereby misapplied and wasted. The use of the device is also illustrated in Plate XXXIX, Fig. 2, where *k* is the poison-can hung on the shoulders, *r* its opening, *h* a suction-hose from the interior to the cylinder, *c*, moved back and forth on piston, *x*, which is held firm by the right hand and with its extension-pipe, *x u*, holds the nozzle, *u s*, to direct the spray, *u s*. The nozzles are also shown in Fig. 3 and Plate XL, Figs. 5 and 6. By another arrangement, Plate XL, Fig. 6, above alluded to the extension-pipe is attached at n angle to the side of the discharge end of the cylinder and the suction-hose coupling is at an angle, or preferably a curve, diverging to 45° or more, to allow the hose to hang at an angle with the cylinder without kinking.

Where one and the same person must at the same time direct the spray and also do the pumping, the telescope pumps, or hydronettes, are preferred to the "aquapults," "aquaject," and all other forms of pumps. No other pumps allow the operator such freedom of action or facility in applying the spray in any direction or position without con-

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fliction with the pumping. The greatest freedom in the use of this implement is attained by inserting its suction-pipe in a knapsack-can for the poison liquid. To pump from a vessel which must rest upon the ground the pumping has to stop whenever the position of the vessel is to be changed. A second person can carry the receptacle, but this is really less satisfactory and far less economic than to use the knapsack-can. This combination of such pumps with the knapsack-can was patented (No. 209668) as a "fire extinguishing apparatus" by Messrs. J. E. Condict and Albert J. Doty, of Philadelphia, Pa., on November 5, 1878. These pumps also have a wide application for various purposes, such as washing windows, vehicles, &c., which gives them a great value in addition to that for throwing poison. The combinations already noticed are best suited to apply the poison on small patches of the plants, or where the worms have appeared only in some isolated spots in the fields; but for general, broadcast poisoning they have been more successfully used on horseback or from a cart or wagon.

A horseback method of employing these pumps may be illustrated by plate XLI, Fig. 1, which represents one being operated to take and distribute the poison from a pair of rubber bags hung across the back of a horse. The two bags are joined above by straps, and in front are provided with hose-pipes which unite with each other and with the suction-hose of the pump. This point of juncture is seen in front. These bags, though somewhat costly as compared with other horseback receptacles for carrying poison, answer the purpose well, and their use for poisoning cotton fields has been due to the ingenuity of Capt. Jackson Warner, of Austin, Tex., who has manufactured them for some years in combination with another pump.

The use of an eddy-jet and *extension-pipe* such as is presented in Plate XXXIX, Figs. 2 and 3, for delivering a good spray at a safer distance from the rider, is an improvement introduced for all broadcast distributing apparatuses as well as for applying poison to the nether surfaces, and these will be used to much advantage with the various kinds of horseback receptacles already devised. The person wearing the knapsack apparatus shown in Plate XXXIX, Fig. 2, can use it for broadcast work on horseback, in which case he may still wear the can upon himself or he can hang it upon the saddle or horse, as he chooses. Also, by duplication, a pair of such cans, with or without a sipho connection, and hung across the horse, answers well to give balancement and supply the pump.

The method of using these pumps from a barrel or tank *in a cart or wagon* is illustrated in Plate XXXVIII.

"The most common mode of using them is the following: A barrel containing the liquid is put on a cart or wagon and drawn over the field. One hand is employed, if necessary, to keep the poison stirred up, while three others, each with one of these pumps, apply the liquid from the rear of the wagon, one taking charge of the three inner rows,

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the others each about three more rows on either side. In the use of this and of all other pumps it is advisable to add a strainer to the lower end of the hose in order to prevent impurities from entering the valve. In an emergency, where no machines are at command, these fountain pumps do excellent service, and many prefer them to other means of applying the poison. They are, however, wasteful of material, and the poison is more apt to get on to the bodies of those employed in their use than in most of the other modes of sprinkling."

Three or four of these pumps may be operated in the same cart and from the same tank, and the vehicle can be driven very rapidly in cases of haste. Mr. P. Calahan, of Selma, Ala., informs me he prepared rough carts with short axles, upon which he used his ordinary wagon wheels, and, driving on a rapid trot with the barrel of poison and fountain pumps on each, with occasional change for a fresh team, each cart poisoned forty acres per day. As set forth elsewhere, it is certainly a very considerable advantage to have less than four wheels to the vehicle, as it can then be turned shorter and driven quicker and with less damage than is possible with the ordinary lumber wagon. In this connection the reader will do well to notice the high legged wheels described in the elevated frames of machines in the following portion of this report. These same legged wheels apply equally well to carts, and so used will save more of the crop.

By using the wheels from a wagon or any wheeled farm machine, a simple cart for conveying poisoning apparatus is easily constructed with a wooden or iron axle, or with legs for the wheels. It must be remembered that shafts, if used in their ordinary position upon carts, place either the horse or the wheels upon the rows. If shafts are employed they must be set to one side. This produces a side-draft uncomfortable for the horse. Where a special axle is to be made it can be given length enough to cause the wheels to straddle a pair of rows; then the shafts and horse may be centrally placed over the intermediate row-interspace; but when an axle of usual length is taken it will generally be better to use a median tongue above the row and a span of horses ahead of the wheels; and a tongue can generally be more easily found or made than a pair of shafts.

Concerning the use of the "fountain-pump," we quote from the Department Report "On Cotton Insects," 1879:

"The most practical way of applying wet poisons that has come under our observation is by means of a machine known as the fountain-pump.

* * * * * * *

"In using the fountain-pump, one man works the pump, another hand (often a woman) accompanies him and carries the bucket containing the mixture. Other hands keep these supplied with the poison. As some parts of the work are more tiresome than others, the hands are transferred from one part to another at intervals. The water is conveyed to and about the fields as far as possible in wagons.

"It is estimated by those who have had much experience in applying poisons in this way, that where water is easily obtained, with one fountain-pump and eight hands (three of whom may be women) 25 acres of cotton may be poisoned in one day. The

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eight hands are distributed as follows: One works the pump; one carries the bucket from which the poison is pumped; three supply this one with the mixture; three are with the wagon getting water and mixing the poison.

"Although the plan just described is the one most generally used, we think that adopted by Mr. Trelease during the present season is preferable, requiring as it does fewer hands.

"A 40-gallon barrel containing the mixture is placed on an ordinary four-wheeled wagon, the wheels being 5 feet apart, and the lowest axle 23 inches from the ground. The wagon is drawn by two mules, these walking in the furrows on either side of the row of cotton over which the wagon passes. One hand drives the team and two others, provided with fountain-pumps, distribute the poison from the barrel. In this way nine rows of cotton are poisoned each trip across the field. In ordinary cases one or two other hands with a team can keep these supplied with water. By this method poison can be applied very rapidly and with a minimum number of hands. The experiments show that the cotton was not seriously injured by the team or wagon, although much of it was as high as the top of the wagon-box, and there was none that was not bent as the axle passed over it. Certainly the time and labor saved will, except in cases where the cotton is very high and closely interlocked between the rows, more than pay for the injury done to the cotton. I suggest the following improvement to the apparatus used this season: Have a cover fitted to the barrel to prevent the spilling of the poison. This cover should have three holes; one for a dasher (similar to that used in churns) for agitating the mixture; the two other holes to admit the hose of the pumps. The dasher may be worked by a boy or the men with the pumps.

"Although the method above described is the most practicable yet devised, we feel that it can be improved upon. Our observations convince us that the thing most needed is a machine which can be drawn by one or two horses and which will throw a spray of water on the under side of the leaves.

"The present modes of poisoning are defective in that they require a large force of hands, often when there is much other work to be done; and what is a much more serious matter, as the poison is applied to the upper side of the leaves of the plant, the young larvae are not killed until they are large enough to eat through the leaves. This would be of less importance could the poison be made to adhere to the leaves; but it often happens that the mixtures are washed off the plants by rains soon after being applied, while if they were applied to the lower surface of the leaves all larvae feeding at this time would be poisoned, besides there being less liability of the poison being washed from the plants."

In addition to what is quoted above Mr. Trelease also reported as follows:

"All of my wet poisons were applied by use of Whitman's fountain-pump, No. 2.

* * * * * * *

Meantime, one or two other men, with a two-horse wagon, containing several smaller barrels, were engaged in carrying water from a pond to the end of the rows of cotton, where it was transferred to the distributing wagon. With these two pumps worked slowly, the mules walking very slowly, we found that a barrel of water went over about three acres of cotton, wetting it fairly, but not so well as was to be desired. The men were therefore made to work the pumps faster, so that a barrel lasted for two acres. Not satisfied with this, we enlarged the holes in the rose-nozzle a little, so that without materially diminishing the force of the pump we were able to apply a barrel of fluid to the acre.* In this way about 30 acres a day may be poisoned by four hands and four mules.

"With our single pump we were able to cover only five rows of cotton for each trip

* It is far better to employ the larger size of pump, which, from its greater capacity, distributes more water than the one used by me, and with less labor.—*Ib.*

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across the field and do it well. Including the time spent in filling the barrel it took forty-five minutes for each barrel of poison put out; or, in ten hours, three hands and four mules would poison about 13 acres."—*Ib.*, p. 225.

Concerning these statements it should be added that (1) in the light of more recent improvements by this method the poison is not applied "with a minimum number of hands"; (2) the enlargement of the holes in rose-nozzles is objectionable as impairing the quality of the spray by increasing the quantity of liquid thrown; and (3) if a larger pump of the same kind is used to distribute more water, it will not be "with less labor," for with the same style of pump the mechanical rule must be that the labor varies directly in proportion to the capacity or to the quantity distributed.

It seems that in former reports only the single-acting hand-pumps were alluded to or recommended. By looking up everything in the trade and in the Patent Office, so far as my time would permit, it has become possible to report upon quite a number of others, some of which, as noticed above, are *double-acting*, and hence much preferable to those which were formerly represented as the best.

In this connection it should also be added that although the hydronettes and fountain-pumps are certainly the best hand-pumps, and, indeed, excellent for throwing broadcast sprays from barrels or tanks and for applying single jets beneath plants, yet we cannot regard those heretofore made as the best barrel-pumps or tank-pumps, since others more suitable for such purposes will be noticed more properly under the title of "Barrel and Tank Pumps," further on.

Finally, it should be added that there are, besides these described, *other patented modifications* in pumps of the above group, but which have not yet found the trade to much extent. It is probable that they will not compete successfully with those presented above, and in most cases they add complication and expense of construction. Their most noteworthy features may be briefly noticed in chronological order. That by Mr. T. J. Mayall, of Boston, Mass., as patented April 16, 1872 (No. 125824), has a valve in the discharge end of the piston, and close below this a valved suction-inlet through a side-haft to the piston. This enables the nozzle to be held steady, and not have a reciprocating motion, only the cylinder being slid back and forth. Another patent (No. 129750), issued July 23, 1872, to Mr. W. B. Robins, of No. 1, Upper Gordon street, Euston square, Middlesex County, England, has for its most important feature the introduction of an air-chambered coupling between the suction-hose of a hydronette and any supply pipe which may be connected thereto. Again, in No. 139263, on May 27, 1873, Mr. Robins patented the addition of a third or outside concentric cylinder with a third valve (of annular form) to provide double suction; the suction being continuous during both strokes of the piston, in single acting, or intermittently discharging hydronettes. Also, in No. 154343, on August 25, 1874, the same gentleman patented in the piston of a

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single-acting hydronette a flexible cup-packing above an annular slip-head which strikes into the cup to spread it at the force stroke. Mr. F. S. Shirley, of New Bedford, Mass., in patent No. 173349, February 8, 1876, introduced in the single-acting hydronette a tubular air-chamber surrounding an inward projecting discharge-pipe (and which can only be of value when directed above the horizontal), a strainer in the piston-head, a piston and handle of one piece, and a cylinder and stuffing-box of one piece. In No. 199380, January 22, 1878, Mr. W. F. Raymond, of Brooklyn, N. Y., introduced the double-acting discharge in combination with double-suction and the tubular air-chamber by using five valves and the third or outside cylinder already noticed. Mr. A. Hamilton, of New York City, patented, September 13, 1881 (No. 246880), a hand-pump differing from the best hydronettes chiefly in its combination of a rose and solid jet nozzle with a shut-off cock and by the complex construction of the piston head and valve.

AQUAPULTS, AQUAJECTS, AQUARIUS, EXCELSIOR, AND HYDROPULT.—(Plate XL.) Under these names are known small portable pumps which have a side discharge from the *upper* cylinder-cap, while they are worked by a T-handle on top of the piston. When in use these pumps are generally supported in a more or less vertical position by the operator, and the cylinder is often held by some kind of attachment to the receptacle for the liquid or by a foot-piece upon the ground or floor. Being thus planted the weight of the body can be thrown on the piston during the downward stroke, but the upward stroke is more difficult. Some are double-acting, and most have an air-chamber upon the cylinder or in the piston. The market prices of these pumps range from $8 to $10. The various kinds that have come to my attention merit the following notice:

The former Cotton Worm Reports make no allusion to these pumps, yet there are several which seem to deserve consideration here.

"*The Johnson Force Pump*" appears to be the earlier form of the "*Aquapult*." Mr. W. J. Johnson, of Newton, Mass., took out patents No. 30480, October 23, 1860, No. 6649, September 21, 1875, and No. 116599, July 4, 1871, relating to the following pumps: Plate XL, Fig. 1, represents his pump in combination with a bucket for the liquid. The T-handle, *t*, is seen on top of the large piston-rod, *p*, which is hollow and of half the size of the outside cylinder, *k*. About midway of the cylinder is clamped fast a bracket, *b*, with claws that clinch firmly upon the edge of the bucket. The discharge takes place through a hose, *h*, attached near the top and having a terminal nozzle, *n*, of the kind described on page —, and in Plate XV, Fig. 5. The pump is double-acting, works easily, and is powerful in its action. It is manufactured by the National Manufacturing Company, Boston, Mass. Other manufacturers and inventors have introduced modifications in some of its details. This form of pump as manufactured by Messrs. W. & B. Douglas and patented (No. 192979, July 10, 1877) by J. W. Douglas, all of Middletown, Conn.,

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has the bracket in the form of a kneed leg, bearing a flat foot-piece at the side of the bucket and upon the ground. Under the patent, No. 209513, October 29, 1878, of Mr. A. B. Prouty, the National Manufacturing Company makes this pump having the leg sloping and nearly straight as it extends from a foot-plate upon the ground to the upper cap of the cylinder, where it is hinged fast so that it can be folded parallel against the cylinder. The discharge spout has a handle formed upon its base and bears a peculiar terminal nozzle that hangs when out of use upon a hook, while the upper cap of the cylinder has a projecting ring by which the whole device may be hung. In this form the foot-piece will hold the pump stable in a deeper vessel, and it may be thus held inserted in the side bung of a barrel, in a tub, or large can.

The most decided variation upon the "Aquapult" was introduced by Mr. Johnson in his patent, No. 116599, of July 4, 1871. Its shape is shown in Plate XL, Fig. 2, where *h* denotes the suction-hose; *m* the handle, and the discharge is downward. It consists of an "Aquapult" having the suction entrance at its side, *o*, while the cylinder discharges at its top into an ensheathing cylinder, *k*, which discharges at the lower end. In this form the pump subserves the purposes of a ***hydronette*** or ***syringe***, and has also the advantage that the reciprocating motion of the piston does not disturb the position of the nozzle, which is held immovable with the cylinder. An extension pipe, Fig. 5, should be added.

Next should be noticed two styles of pump which are allied to the "Aquapults" by both form and adaptability. The "***Aquarius***" and the "***Aquaject***" (Plate XL, Fig. 3) have external resemblance to each other, but are different in operation and internal construction. The "Aquarius" is manufactured by Messrs. W. & B. Douglas, of Middletown, Conn., seemingly under the patent, No. 33299, issued September 17, 1861, to Mr. B. Douglas. It is a strong pump, but is single-acting and, although provided with an air-chamber upon the cylinder, the jet thrown is of an intermittent character. The "Aquaject" as made by Messrs. Rumsey & Co., of Seneca Falls, N. Y., throws a good, strong, steady jet, being double-acting and also possessing an air-chamber. In Fig. 3 the operator is working the piston by his right hand and holding the cylinder by its foot-piece, the pump takes water by a suction-hose leading from a bucket to enter the side of the base of the cylinder while the water is discharged through a hose held in the left hand and leading from the upper cylinder cap to which it is joined at a point beneath the globular air-chamber which surrounds the piston. Both of the foregoing pumps are strong in action and durable in construction. They cost from $8 to $10 each. The suction-hose can have greater length and be inserted in a barrel or other larger reservoir upon a cart or otherwise when desired, and the discharge hose may bear a spray nozzle or be connected with the main of any system of branching pipes. These and the "***Aquapults***" are very desirable for squirting upon trees

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and fires, but in barrel and tank pumping or wherever greater force is commendable a levered force-pump will generally be preferred, and such will be described further on.

In No. 150836, on May 12, 1878, Mr. R. T. Deakin, formerly of Sheffield, England, but now of Philadelphia, Pa., patented his so-called "*Excelsior Pump* and portable Fire-extinguisher," which has a flange-shaped foot-piece and combines in itself the characteristics of the double-acting "Aquapults" and "Aquajects." This pump works well and will rank with those above described.

Here may be appended a notice of the so-called "*Hydropult*," of which Mr. W. T. Vose, of Newtonville, Mass., is the patentee and manufacturer. His letters patent date November 15, 1868, and extension November 15, 1878. This pump is represented in Plate XL, Fig. 4. The two cylinders, *k k*, are continuous by the U-coupling mounted on the large stirrup-shaped foot-piece, *p*. A pair of pistons joined above with each other and with the single handle, *m*, work up and down together and simultaneously in the cylinders. The suction-hose, *h*, from a bucket or other receptacle, communicates, at *i*, with one cylinder, while the other cylinder has an air-chambered discharge, *ae*, near its top. The operation is as follows: The upward stroke causes the water to pass through the first piston-head and fill the U-coupling and both cylinders. The downward stroke discharges about all of this up through the second piston and ejects half of it from the spout. The second upward stroke ejects the other half or the contents of the second cylinder while both cylinders are simultaneously filled by the suction. Thus the entire contents of one cylinder is thrown out at each stroke, while the upward stroke also sucks both cylinders full. This device is more complex than the pumps noticed above and suffers more friction while it does not work as easy as the others, yet it is a reliable pump capable of such uses as the "Aquajects" are adapted for.

BUCKET-PUMPS AND KNAPSACK-PUMPS (Plates XLI and LV).—Besides the "Bucket-pumps" and "Knapsack-pumps" already noticed, numerous others are made for extinguishing fires, sprinkling plants, etc., but in general they are such as have little value in the treatment of field crops. Yet in this connection it seems desirable to call special attention to the following examples:

Plate XLI; Fig. 3, illustrates the three forms of "*Lewis's Combination Force Pump*" as manufactured by Mr. P. C. Lewis, of Catskill, N. Y., under his patent, No. 230639, August 3, 1880. It is a *syringe* of large size, having a double-cupped rubber piston-head and three substitutive discharge attachments. In the one case the solid jet nose-piece or injector-spout is screwed on. In its stead a rose-head face may be used, making of it a spray-syringe, his "Potato Bug Exterminator." Thirdly, an end-piece having a suction hose, suction valve, and a side discharge spout may be attached, thus producing a simple single-acting force-pump. The discharge spout, as shown in the figure, has a short hose-

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extension bearing a nozzle, to be held in one hand. This nozzle is described on page 209, (see Plate XIX, Figs. 6 and 7.) As a cheap pump extensively advertised it has had a good sale and given considerable satisfaction. The "Combination Pump" made in brass, retails at $5.50. A hook is provided for attaching the base of the pump, but, as in other pumps of this class, generally there is wanting some better means of support to sustain the cylinder in an upright position and so leave the left hand free to hold and direct the nozzle, while the other hand works the piston.

The sketch in Plate XLI, Fig. 2, represents a pump-support, patented in No. 124593, March 12, 1872, by Mr. C. G. Korth, of Carlstadt, N. J., and shows an attempt to supply in pumps of this class something to make their use more convenient. It consists of a crutch attached to the pump and serving as a fulcrum for its lever. The top is held firmly in the arm-pit while the sharp pointed base of the pump presses against the bottom of the bucket, barrel, or other receptacle for the liquid. This leaves one hand free to hold the nozzle. The other features of this pump appear in no way novel or superior, but the inventor controls the use of his support in pumps of all kinds.

The following bucket-pumps and knapsack-pumps, which are occasionally offered by the trade, seem not the most desirable for poisoning the crop, though some on the list are well suited for other purposes and some exhibit features which may be hereafter combined in the pumps which are best adapted for our purpose.

In patent No. 212067, February 4, 1879, Mr. A. Stoner, of Stony Point P. O., East Baton Rouge, La., claims some details in a simple pump of this type which seems to have no very special advantage for our present purposes.

Mr. W. W. Mallory, of Holland Patent, Oneida County, New York, obtained in a pump similar to the above, and in patent No. 237193, February 1, 1881, a pump-cover, consisting of a tube which bends horizontally and then downwards as a handle, overflow spout, and guide to the piston-rod, which works through a hole in its top.

Patent No. 92194, July 6, 1869, secured to H. and A. Kaiser, of Columbus, Ohio, a pump of this kind but permanently attached inside of a common watering-pot, its basal branch-spout with excurrent valve, coincides with that of the pot and bears a rose or substitutive solid-jet nozzle as desired.

A pump granted in patent No. 86287, January 26, 1869, to Mr. A. M. Dix, of Shelton, England, has the cylinder-cap clamped to cross-bars inserted in the upper part of a suitable receptacle. There is a stuffing-box above for packing, and below this an outlet from the upper part of the cylinder is extended downward by a drip-tube upon the side. A diaphragm-strainer is inserted in the chamber of the discharge-valve.

A pump having similar construction to those just noticed, but with the valves reversed, giving suction through the basal branch-spout and

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discharge directly from the basal axis of the cylinder, appears in patent No. 108087. This enables it to be used as are syringes and other hand-pumps of the single-acting kind.

Mr. E. M. Crandal, of Chicago, Ill., patented, in No. 175039, March 21, 1876, a pump bearing a bucket on the tops of its parallel pistons and air-cylinders, which are mounted on a foot beneath. The pump has a lever with its end hinged to the edge of the bucket and its middle to the piston-rod. This bears a perforated head and valve allowing the liquid from the bucket to gravitate and suck through downward when the piston is raised. The valved branch-spout, excurrent from the base of the piston-cylinder, leads through an air-cylinder, which has a hanging discharge-spout reduced for a hose extension.

A pump having basal suction but otherwise like the foregoing and immersed entirely inside of a bucket was patented in No. 187496, February 20, 1877, by Mr. W. Westlake, of Chicago.

The two last-noticed apparatuses have value chiefly as cheap garden sprinklers and window-washers.

In such pumps, with solid piston-heads as have been noticed above, Mr. J. M. Holland, of Wilmington, Del., has introduced a simplification consisting of a piston-rod, handle, head, and guide all cast in one piece and covered by his patent No. 206451, July 30, 1878. The pump with which he has combined it more specially is double-barreled, the larger barrel being an air-chamber surrounding a hanging discharge-spout.

The "Patent Knapsack Engine," manufactured by Messrs. W. and B. Douglas, of Middletown, Conn., is not handy enough for field work. It consists of a pump, probably similar to the "Aquarius," inserted in a can.

The fire-extinguisher of Mr. J. W. Stanton, of New York City, and patented in No. 223402, January 6, 1880, can be used for broadcast work over very small patches, but is like the preceding apparatus in not being handy for field use. It seems to consist of an "Aquapult" inserted firmly in a can. Its nozzle is novel, as noticed above.

An insect-destroyer, consisting of *a bucket* with a deeply-recessed bottom, with a rose pendant in the center of the recess and a cylinder therefrom extending into the bucket to admit water by perforations in its sides when a weighted or spring valve or valve-piston is lifted in the cylinder by a piston-rod terminating in a finger-loop beneath the handle, was patented in No. 193417, July 24, 1877, by Mr. F. J. McDonald, of Madison, Ohio. Also a similar device was patented in No. 209372, October 27, 1878, by Mr. W. B. Allen, of Orleans, N. Y. These (Plate LV, Figs. 1 and 2) allow the spray to descend only at the will of the operator, and with a force greater than it would receive from the weight of the liquid alone. Such cans avoid the tilting of the vessel which is necessary with the ordinary watering-pots, and are thus more convenient.

Related to these is the "poison distributor" of Messrs. J. Amor and

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A. J. Lane, of Glenville, Ohio, as patented in No. 226588, April 20, 1880. It consists of a knapsack of cylindrical form having a piston of its inside diameter held down by a strong spiral spring. The piston-rod is exserted above, whereby it is raised and the spring is compressed until the can is filled. Then the spring is allowed to press the piston upon the liquid which finds exit by a side tube near its base. A hose extension bears a stiff tube having a thumb-levered valve and rose. The can is carried on the back by loops over the shoulders. Of its practicability I am unable to speak, except that it has not a promising aspect.

A simple rose-syringe, having its middle two-fourths surrounded by a large concentric cylindrical can for the liquid that can enter the syringe by perforations which the piston-head may close when pushed down, was granted as an insect-destroyer in patent No. 216679, June 17, 1879, to Mr. G. H. Hull, of Montello, Marquette County, Wisconsin. The instrument thus has no valves but the piston-head, and should prove superior to the ordinary watering-pots and syringes. Prior to this, however, there was issued to Mr. G. T. Wisner, of Florida, Orange County, New York, in No. 193742, July 31, 1877, letters patent on a "Potato-bug Poison-syringe" having the same general plan as that just noticed, but differing chiefly in possessing two piston-packings and a funnel-shaped receptacle surrounding it.

BARREL AND TANK PUMPS AND APPURTENANCES. (PLATES XLII, ET SEQ.)—Besides the devices already noticed as employable with barrels or tanks forming parts of machines or carried upon vehicles, or hauled upon legs having wheels or runners, or upon horseback, certain barrel-pumps and tank-pumps proper and appurtenant machinery deserve special consideration as follows. Many of these are presented here only as parts of the history of this subject, while some have a very decided value.

[*Single acting, discharging from below the Piston.*]

J. C. Melcher's Patent Spray Pump.—Among the earlier pumps used especially for the cotton crop should be mentioned that of Mr. J. C. Melcher, of Black Jack Springs, Fayette County, Texas, which embodies his patent of January 18, 1876. At present our knowledge of it is based only on a very rough wood-cut and circular. The pump can be made either of sheet metal or stronger metal and may be worked with or without a lever. The lever was fixed to the head of a barrel by a vertical rod, as with Mr. Ruhmann's (see further on). The cylinder of the pump was inserted through a large hole in the head of the barrel and had a cloth suction-strainer below, while its top appeared fastened by a collar around the piston and having two opposite strips extending laterally downward to the head of the barrel, allowing the pump to be rotated on its axis, to direct the spray. The discharge-spout is long, bearing a biconic air-chamber above and a large, single, terminal nozzle for broadcast sprinkling, appearing to be the

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same as that described on page 196. Mr. Melcher, who is an inventor of various contrivances, strongly recommended his pump to the public. His nozzles are much used and are still made by him and by others.

The Charles Vogelsang Spray-pump for Poisoning on Cotton.—Mr. Charles Vogelsang, of Round Top, Fayette County, Texas, patented, in No. 194388, August 21, 1877, a sprinkling pump with nozzles as shown in Plate XLII, Figs. 5, 6, 7, and 8. The T-handled, solid plunger, *h*, works in a thin cylinder having a basal suction-strainer, *a*, and valve, with basal discharge-valve, air-chamber, *d*, and spout, *e*. The spout, *e*, chamber, *d*, and cylinder, *b*, are about equal in length and joined together compactly side by side, the spout having a crook at its top on which various nozzles may be used. In his letters patent are figured and described the concave and scoop-shaped spray deflectors and quadrant-shaped and circular nozzles with many-punctured periphery.

Another pump of the same type and embracing some of the details of the two just noticed, with some additional peculiarities of little value, is that made by Mr. Ruhmann.

"*The Ruhmann Sprinkler.*—Invented by Mr. Julius P. Ruhmann, of Schulenburg, Tex. (patent No. 206901, August 13, 1878.)"

In Plate XLIV, Fig. 5 is a longitudinal section of the machine; Fig. 4 shows the connection of the pump-cylinder with the air-chamber; Fig. 6 represents the strainer; Plate XV, Figs. 6 and 7, the nozzle, showing the arrangement for cleaning the same; and Plate XLIV, Fig. 3, shows a modification of the discharge-pipe.

"The letter *a* represents the reservoir for holding the poisonous liquid; *b* is the pump-cylinder, in which the piston, *c*, is worked up and down by means of the lever, *d*. The lower end of this cylinder is made funnel-shapped, and to it is fastened the rubber tube, *e*, which connects it with the strainer, *f*. This strainer is made in two parts for the introduction of a straining-cloth, *g*, and for convenience in cleaning. The lower end of the strainer is perforated, and, if desired, any additional straining matter may be placed between the perforated bottom and the cloth, so as to make sure that no substances shall be forced into the sprinkler to clog its action. To the lower end of the cylinder is secured the discharge-pipe, *h*, upon the top of which is formed the air chamber, *i*. Upon the outer end of the discharge-pipe is placed the sprinkler, *l*, which is round and flat, as shown, and perforated about one-half around. Upon the top of this sprinkler is screwed the cap or cover, *m*, secured to which is the brush, *n*. The handle of the brush is bent at right angles, as shown, and is secured to the cap in such a manner as to form, as it were, a part thereof, so that as the brush is moved around to clear away any obstructions which may have a tendency to close up the fine perforations in the edge of the sprinkler the cap turns with it. By means of this screw-cap the brush can be adjusted up and down at will, so that after cleaning off the perforations the brush can be depressed down below the level of the holes, so as to be out of the way."

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Instead of a single nozzle, there may be two or more used by simply changing the construction of the discharge-pipe, as in Fig. 3, which represents one made for the use of three nozzles.

The nozzle seems to embrace about all that is decidedly novel in this apparatus. Mr. Ruhmann's cone-deflectors are also used by him on this pump and upon its three-branched pipe. The cone-nozzles and their combination with the pump may be seen in Plate XLIV, Figs. 2 and 3. This pump has been used several times in these experiments. In getting bent easily, it is like all the pumps having single-walled, thin cylinders, and the piston does' not fit perfectly, so there is an excess of overflow.

The A. J. Polansky Spray-pump is that described in patent No. 238430, March 1, 1881, by Mr. A. J. Polansky, of Fayetteville, Fayette County, Texas. Here also I find no novel points of special value in the pump proper, but the combination with his sprinkler nozzle is covered. The latter, as described on p. —. (see Plate XXIII, Figs. 3 and 4), consists of a vessel having peripheral perforations and a deflecting flange with a simple device for returning the drip to the reservoir. These arrangements are only slightly different from Mr. Schier's.

Schier's Spray-pump, being made by Mr. John Schier, of Ellinger, Tex., is represented in Plate XLII, Fig. 4. The device, *n*, for spraying and returning the drip is described already (see Plate XXIII, Figs. 1 and 2). A modified form of the nozzle for use on a hose has also been described. On the discharge spout, *a*, is mounted a link, *x*, as a lever-fulcrum, and below this is a large perforated cup, *e*, which fits as a bung in the perforated top of a barrel, or other reservoir, and still lower is the cylinder, *c*, in which the piston, *p*, is operated by the lever, *l*. The cylinder-top is so low that the overflow back into the barrel is not observed. The strainer and valve arrangements are essentially the same as in the pumps just described. The pipe, *a*, probably contains an air-chamber inside of or surrounding its discharge-passage.

Pumps having lever, piston, cylinder, and stock proportioned similar to the latter, but with somewhat different discharge, were described in patent papers by Mr. John Butman, of Milan, Ohio, in No. 178230, June 6, 1876, and by Mr. T. K. Ball, of Maysville, Ky., in No. 195076, September 11, 1877. The latter claims an *agitator*, which should be described in this connection, as shown in Plate XLII, Fig. 3, where *b* represents the cylinder, *h* its suction-end, and *c* its piston-rod, to which are attached the stirrer-rods, *d d*, bearing the dasher-plates, *k*. These are moved up and down with the piston, and by their churning action keep the other substances mixed with the water.

An important step in the construction of cheap sheet-metal pumps was made by Mr. J. G. Evenden, of Chicago, Ill., as claimed in his patent No. 140022, reissue No. 5864, May 12, 1874. His first claim is "In a hand-pump for liquid vessels, the combination of a pump cylinder

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with an air-chamber surrounding the cylinder." Thus, although the outside casing of the air-chamber may become accidentally bent, that of the cylinder within is protected against such injuries. Also this construction gives such pumps a more compact form, rendering them simpler and stronger. The pump is shown in section in Plate XLII, Fig. 2, where *h* is the handle, *b* the solid piston in the cylinder with a guide-cap, *c*, at its top, incurrent valve below, and excurrent valve, *l*, to the air-chamber, *e*, which surrounds the cylinder as shown. A stiff discharge-tube, *a*, penetrates this chamber from its top to near its base, while its upper part has a horizontal tube, *m*, from the cylinder, as an air-vent, which also communicates with an overflow-pipe, *n*, extending downward on the outside of the air-chamber. In cheap pumps made of thin sheet-metal this protection of the working cylinder by an air-chamber encasement is certainly a very good plan. The air-chamber may fit as though it were a bung in a large hole through a fixed or removable head or septum of the vessel, and attachment by a flange or otherwise is easily contrived.

The Helmecke Spray-pump is of the same description with slight modifications consisting chiefly in placing a lever upon the piston, and the overflow-pipe inside of the air-chamber as patented in No. 206448, July 30, 1878, by Mr. F. A. Helmecke, of Round Top, Fayette County, Texas. This pump is illustrated in longitudinal section in Plate XLII, Fig 1. The lever, *c*, is linked (*x*) to a pivot above the discharge spout and works the plunger, *b*, in the cylinder, *a*. Below is a suction-strainer and valve, *v o*. Higher is an outlet valve, *d*, to the air-chamber, *e*, and discharge-spout, *f j*, while much higher is the overflow-pipe, *e f*, extending down through the air-chamber. Being entirely round on its outer surface the pump is readily inserted in a large bung-hole of the barrel or poison-receptacle and is thus held while being worked.

A pump having its cylinder protected by an air-jacket was also made and used in Fayette County, Texas, at about the same date as the latter in an apparatus which has been thus described by Professor Riley:

"THE YEAGER SPRINKLER.—This is a sprinkler invented by Mr. George Yeager, of Flatonia, Tex., (patent No. 204410, May 28, 1878). Plate LIV, Fig. 6, is a part sectional side view, and Fig. 7 a plain view thereof.

"It consists of a platform, A, upon which is laid a barrel, B, containing the poisonous liquid. A rubber hose, C, connects this barrel with the bottom of a pump cylinder, D. This cylinder is supported on a step, A^1, and its upper end held in a brace, A^2, attached to a standard, A^3, which rises from the platform, A. E is the pump-plunger, connected to a lever, F, which is pivoted in the upper end of the standard, A^3. The liquid poison is forced out through the sprinklers, G G G, which are three in number, and throw the water in a fine mist over three rows of cotton. A rubber hose, I, is attached to each of the spouts, H, of the pump to form connection with the sprinklers G for the purpose of lengthening or shortening the spouts, especially the two on opposite sides of the pump, and of detaching and cleaning the sprinklers. The upper end of the pump-cylinder is left open and a spout or tube, J, is connected thereto to conduct the liquid, which would otherwise be wasted, back into the barrel.

"The connection of this waste-pipe with this machine is the only point which is

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claimed as new by the inventor. The sprinklers or nozzles are not further described, but it is to be understood that the spray is produced in the same way as described in this class of sprinklers."

Mr. Yeager's nozzle was patented September 2, 1879, and has been described on p. —. This and the more recent form of Mr. Yeager's apparatus is further illustrated in Plate XLIII, Fig. 1. The pump is represented as inserted in the side-bung of a barrel. The lever is indicated by *f*, its fulcrum by *i*, and the piston by *p*, while *j* is the over-flow-pipe leading back to the barrel, inside of which is seen the cylinder, *k*, having a T-shaped suction-strainer below, and a ridge-like discharge-passage, leading to the spout, e^1, which bears the nozzle, *n*, from which the spray, *s*, is ejected. The method of removing clogging matters from the nozzle chamber is also depicted; one of its screw-caps being removed the finger is used to wipe out the interior.

The Pinter spray-pump is that patented in No. 233431, October 19, 1880, by Mr. F. T. Pinter, of Schulenburg, Fayette County, Texas, as shown in Plate XLIII, Figs. 2 and 3. It will be seen that the arrangement of the pump and barrel is essentially the same as has been noticed above. The parts have the same letters and explanation as given for Mr. Yeager's pump; but in Mr. Pinter's device the piston is worked by motion communicated to it through the draft-wheel crank 1, pitman-bar 2, cranked and pinioned mandrels, *f*, cranked pinions, *h*6, and second pitman, *p*. This particular mechanism for transmission of motion, as shown, is not the most practical that can be devised for the purpose. The nozzle, Fig. 3, is a segmental half-funnel, with a block, *r*, clamped inside, so as to leave only a semicircular, slot-shaped passage by which the liquid is spread into a spray. Its sectional side is shown at *n*, while *r* designates the block in its interior. Such an apparatus may be used with some success, and it may be passed without further criticism until its actual working in the field can be reported upon.

[*Single-acting, discharging from above the Piston.*]

Small vessel-pumps, having the discharge from above the piston, were patented by Mr. W. L. Chipley, of Lamonte, Mo., in No. 251523, December 27, 1881, and by Mr. A. J. Weith, of Chicago, Ill., in No. 258962, June 6, 1882. They are probably not better than the average of the pumps here noticed, but specimens of them are desired to be tested.

Upon tanks or barrels of liquid such pumps as the following, which are now extensively for sale by the trade, may be used. They are mostly designed as cistern-pumps, or small well-pumps, and most of them might, with very careful cleaning, be employed for lifting water during those parts of the year when they are not in use for poisoning. Only a few examples can be noticed here.

Available cistern or well pumps.—Pumps of the same general pattern as that shown in Plate XLV, Fig. 2, are manufactured by Messrs. Rumsey & Co., of Seneca Falls, N. Y., and by Messrs. W. & B. Douglas, of Middletown, Conn. They are good cistern-pumps and may be used on

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tanks or barrels. For the latter purpose the base-pipe, *x*, is inserted through a hole in the cover and extended by a piece of suction-hose or metal pipe bearing a suction-strainer in the bottom of the reservoir. The base-flange, *y*, is then screwed down firmly upon the cover. The cylinder, *z*, is of larger capacity than is necessary for spraying, making harder labor than need be with pumps specially adapted for small sprays. The long lever, *l*, needs to be worked slow, but with much strength. Upon the discharge-spout, *s*, is an air-chamber, *c*. The discharge may be taken from the cock, *k*, at the base of the air-chamber, or from a hose attachment at the top, *n*. The latter is of special value in elevating liquid to fill a barrel or tank, while the cock may prevent siphoing through the pipe when the machine is not being operated. Pumps of this general character, and of the smallest sizes now offered, retail at from $10 to $13. The simpler so-called "*Wheel-barrow force-pumps*" and "*Truck-wheeled or Garden-engine pumps*" are of this same general type. These parties also sell the same styles of pumps having side lugs whereby to attach them against the vertical side of a board, frame, or wall. Allied to the latter are their "*Wind-mill pumps*," which have no lever or a removable one. These cost a little more, but may be used to better advantage where the pump is to be worked by machinery.

In a similar way may be employed the smallest sizes of certain standard pumps of essentially the same form as that shown in Plate XLV, Fig. 1. They have a crank attachment between the lever and piston, whereby the short arm of the lever is inside of the top of the cylinder, which is enlarged as an air-chamber, having on top a cap that is not perforated by the piston-rod, and these pumps are known as "*The Lotus pump*," *of Mr. W. S. Blunt*, 100 Beekman street, New York, "*The patent Pendulum force or lift pump*," manufactured by Messrs. W. & B. Douglas, of Middletown, Conn., and "the *Index pump*" of Messrs. Rumsey & Co., Seneca Falls, N. Y. Their prices range from $10 upwards. "The Lotus" has, besides the side-spout, a straight waterway from its top.

The small "*Counter pumps*" "or *Ale and Beer pumps*" of these manufacturers can be used as simple, cheap instruments, throwing intermittent jets and not giving very great power. They cost $5 to $8.

Those of the above-noticed pumps which have an air-chamber get thereby a discharge that is less intermittent, and, although they are somewhat constant-acting, they are not true "double-acting" pumps, but sometimes erroneously bear that title.

[*Double-acting Force-pumps proper.*]

The double acting force-pumps proper, with or without air-chambers, throw a more constant stream, and hence are the best as tank or barrel pumps for supplying continuous jets of spray. They generally discharge from above the piston-head. In these, as a rule, the upward stroke produces a suction, filling the cylinder with the liquid. The downward stroke displaces all this from beneath the piston-head,

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half stopping in the upper chamber of the cylinder, which is reduced one-half by having a lesser diameter or an enlarged piston-rod, while the other half of the liquid is discharged. On the next or upward stroke the half that remains above is discharged while the cylinder is being filled from below. Thus the discharge is one-half at each stroke while the suction is all at alternate strokes. Attempts thus far made to produce suction at both strokes add more complication or inconvenience of form to the pump than the gain thereby will compensate. The reduction for semi-displacement in these pumps is commonly accomplished in one of the following ways: (1) The piston-rod has an outside capacity equal to one-half of the inside capacity of the cylinder; or (2) there may be a median packing septum, and the upper half of the plunger has an outside capacity equaling one-half of the outside capacity of the lower half of the plunger; or (3) the upper half of the cylinder may have an inside capacity equal to one-half the inside capacity of the lower half of the cylinder, in which case two oppositely working piston-heads are used in the respective halves and the cylinder discharge is from a median point; or (4) two cylinders of equal size are used, standing end to end, side by side, or otherwise, with their pistons acting oppositely or alternately to discharge through the same spout, in which cases one cylinder, may discharge through the other, or two separate confluent spouts may be employed for the outlet; or (5) a single piston with a single cylinder, having both suction and discharge at each end; or (6) an arrangement providing suction at both ends and discharge from the piston at one end; or (7) the suction is between the excurrent-valved pistons working together simultaneously in a U-shaped cylinder supplied at one end or at the middle.

A pump arranged on plan No. 7 has been described as seen in Plate XL, Fig. 4, as the "Hydropult" of Mr. W. T. Vose, of Boston, Mass. The plan No. 6 is illustrated in an air-pump contrived by myself, described as shown in Plate XXXV, Fig. 1. The pumps on the No. 5 plan, as heretofore made, are not simple enough to be practical in the work here under consideration. Those of No. 4, which have the two cylinders with contiguous axles, cannot be satisfactorily used except in wells, &c.; also those with two cylinders side by side and with alternating pistons are too complex and lack compactness, while those with two cylinders out of line and the top of the suction cylinder discharging into the base of the discharge cylinder likewise exhibit rather more complication and friction than seem desirable for the work in question, yet one of these which will answer the purpose is represented in Plate XLV, Fig. 4, and deserves more special notice.

The Champion Force pump.—Is manufactured by the Champion Iron Fence Company, Kenton, Ohio, and can be sold at a moderate price. In the figure the pump cylinders, *a b*, are represented as opened upon one side to show the interior parts. Below is seen the suction pipe, *k*, bearing cylinder, *b*, which opens above into the base of the

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cylinder *a*, and this has an upward discharge spout, *e e*, closed above at *p*. This and the standard, *f*, are joined to a flange, *n*, which is screwed to the tank cover. There are two pistons, *p p*, hinged one to either arm of the pump-lever, which has its fulcrum, *z*, upon the standard, *f*. Thereby are simultaneously and oppositely operated the two excurrent valved pistons in their respective cylinders.

A pump after plan No. 2, having a single-headed reduction piston, was patented by Mr. R. Ramsden, April 24, 1860, in No. 28012, but no sample pump involving this principle has yet come to my inspection. The displacement capacity of the upper half of the piston is one-half that of the lower half, which works through a packing, fixed in a septum dividing the pump into upper and lower chambers communicating by an upward valve. The construction is an odd one and may yet prove serviceable.

The counterpart of the latter type is found in plan No. 3, in the reduction-cylinder pumps, which have on the same rod two piston-heads, the upper one of half the capacity of the lower, while the upper part of the cylinder is only one-half as large as its lower part. A large number of these are now patented and being manufactured for wells, yet few of suitable size and weight for use in tanks or barrels have come to my notice. The patent on the reduction cylinder has expired, while the recent improvements are in minor details. Among the pumps of this group available for insecticide apparatuses is one of simple construction and very durable as now made by Messrs. Rumsey & Co., of Seneca Falls, N. Y., under their catalogue name, "*New Style Force-pump*," and another which is really the same thing under a different name, viz: the "*Improved Double-acting Suction and Force-pump*," as described in the sale catalogue of Messrs. W. & B. Douglas, Middletown, Conn. These pumps of smallest size cost from $10 to $12. One of them is shown in Plate XLV, Fig. 3. The suction-pipe, *k*, is to be inserted through the head or cover of the barrel or tank, and its flange, *f*, can be screwed down firmly. An extension hose or stiff pipe may be used to prolong the suction-tube to the base of the reservoir, where an ordinary suction-strainer should be added. The upper or narrow half of the cylinder, *c*, is surrounded by a swollen bulb or air-chamber, *a*. From the base of this is formed the discharge-way, *x y*, having a goose-neck spout, *y z*. The hose may be coupled to the end, *z*, or in place of the neck, at *y*. Since the piston-rod has two bearings in its two heads, its joint, *j*, is essential. It will be seen that the whole is a very strong pump, also serviceable in cisterns or wells. Since the second or upper piston-head takes the place of a cap and packing the pump is in no way complicated, while the air-chamber, in addition to its double action, renders the discharge more constant.

The following list mentions kinds of pumps which are essentially the same as those just described, but less compact in the arrangement of their parts, while they differ *inter se* in several details of little importance in this connection. Though mostly

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available for wells and cisterns, they are, as now made, not so well adapted for use in barrels, &c., though smaller, lighter styles of certain ones could be manufactured on the same general plan that might answer for this purpose.

1. The "Buckeye force-pumps" as now made by Messrs. Mast, Foos & Co., of Springfield, Ohio.

2. The pump patented by Messrs. J. M. & B. Branson, of Flushing, Ohio, in No. 249885, November 22, 1881, and that by Mr. B. Branson, in No. 237240, February 1, 1881.

3 That issued to Mr. R. Bean, of Springfield, Ohio, in patent No. 9873, September 13, 1881, and "Bean's self-regulating force-pump" as now made at No. 6 Loyd street, Atlanta, Ga., Bird & Hannson, proprietors, No. 50 Marietta Street, Atlanta.

4. One granted in No. 238498, March 8, 1881, to Mr. D. Gilbert, of Chambersburg, Pa.

5. That in the patent No. 177401, May 16, 1876, issued to Mr. D. Johnson, of Ashland, Ohio.

6. No. 241572, May 17, 1881, granted Mr. B. C. Vanduzen, of Cincinnati, Ohio.

7. That of Mr. P. A. Myers, Ashland, Ohio, issued in No. 10048, February 28, 1882.

8. Also, the "Red jacket force-pump" as now manufactured by Mr. J. P. Martin, of Cincinnati, Ohio.

The Agitator Barrel-pump, planned and perfected by me in my work for the Department, has already been in Professor Riley's annual report as entomologist, for 1881 (pp. 159–162). The description is as follows:

By reference to Plate XLVI, Fig. 2, the barrel, *k*, will be seen in section, and some of its details, together with those of the pump and stirrer, may be noticed. The fulcrum, *f*, has a foot below screwed to the barrel. Through its top is a pivot, *o*, on which tilts the pump-lever, *l*, which is similarly hinged, at *b*, to the top of the piston-rod, *t*. The pump cylinder, *q*, is also hung upon trunnions, *i*, projecting into eyes. In this illustration the eyes, *e e*, have each a neck fitting in a slot cut through the stave oppositely from the side of the bung-hole, and beneath the stave is a foot on the eye-piece. Its neck is so short that the eye is held down firmly against the top of the stave, while the foot is as tight against its under surface. The length of the eye-piece is a little less than the diameter of the bung-hole, into which it may be inserted to be driven laterally into the slot. The slot is longer than the eye-piece, so the latter may be driven away from the bung-hole for a distance greater than the length of the trunnion-pivot. Then the pump being inserted, until these pivots come opposite the eyes, the latter may be driven back as sockets over the pivots which play in them when the pump is worked. To hold these eyes toward the pump and upon the trunnions a wedge, *v*, is driven in the slot beyond each eye-piece. Thus the pump is easily attached or removed and its union with the barrel is strong and firm. Perchance it be desired that this pump-hole be bunged the side slots may be wedged to make the barrel tight.

The parts of the pump being hung as described, the hinge, *b*, forms a toggle-joint, and in its action causes the pump to oscillate on its trunnions, its basal end swinging wider than its top, as indicated by the dotted line from *x* to *y*. Upon the extremity of this swinging end is a

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oop, *h*, through which is passed a stirrer-bar, *m n*, made to sweep back and forth in the lower side of the barrel, thus to agitate and mix the substances considerably during the operation of the pump, every stroke of the handle causing one or two strokes of the stirrer.

The method of inserting and extricating the stirrer-bar is as follows: It is raised with the pump until the end, *m*, comes opposite the bung-hole. *x*, through which the bar may be pulled out by the cord, *w*, which is attached to the end, *n*, and also preferably to the bungs, *r* and *z*, as shown. Through the same hole the bar may be inserted. This stirring device is the simplest in construction and operation of any yet contrived, while working as it does with reference to the concavity of the barrel it is perfectly effective.

Pumps having other external or internal constructions than those shown here may be similarly mounted, and it matters little if the eye or the trunnion be either on the pump or on the slot-piece. But some of the points in the internal construction of the pump may be briefly noticed here. The lower extremity of the piston-tube is closed and has a circular seat, above which is a slot-shaped entrance to the cavity of the piston-tube. Higher is another circular seat, and immediately above it another inlet to the piston-tube. Between the two seats is a circular slide-valve, which bears a packing on its face and plays loose or free up and down as caused by the pressure to open the lower inlet during the downward stroke and to close it on the upward stroke. The upper cap of the cylinder is quite loose about the piston-pipe, and holds one end of a sheath or tubular packing, the lower free end of which fits snugly around the piston-pipe and tighter to the same when the fluid-pressure is on the outside of it. The piston-tube has about half the capacity of the outer cylinder, and the whole arrangement is such that the pump discharges during both strokes, being a constant-acting or double-acting force-pump, which operates the same whether the discharge be taken from a spout upon the side of the cylinder or from the side or end of the piston-tube. With the discharge from the piston end, and a suction-hose upon its opposite extremity, the pump may be used apart from the barrel, like the so-called "fountain pumps" and "hydronettes" of the trade. Its valves are all metallic, and it may be made for the highest pressures or to throw any volume desired.

This agitator-pump combination was devised for use with suitable apparatuses of all kinds, but in the form here presented it is especially designed for wheeled reservoirs. It works combined with a single delivery-tube or extension-pipe with or without branches or nozzles of any sort preferred. This device embodies the simplest suitable stirrer and double-acting pump for insecticide machines, is perfectly effective, and I have found it the most satisfactory of all tested for squirting.

Conduits, Frames, Portage, and Combinations of Appurtenances, without regard for distinctive pump-characteristics, will receive more special consideration in the descriptions of the following devices, which are

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chiefly of interest on account of the features of their distributing pipes, support, means of conveyance, or other accessories.

One of the oldest devices in our country for throwing liquid poison is a machine thus described by Professor Riley:

"*The Johnson Spray Machine.*—This sprinkler, invented by Judge Jehu W. Johnson, of Columbus, Tex. (patents No. 145571, December 16, 1873, and No. 145572, of the same date), is not only the oldest one on record for the application of liquid poison on a large scale, but produces the spray in a novel and peculiar manner.

"The accompanying sketch, [Plate LIII] represents this machine in operation. It will be seen therefrom that it consists of a tank placed upon a two-wheeled cart. The pump secured to the top of the tank is a common double-acting force pump, and with the discharge-pipe is connected a transverse pipe. These parts need no further description, and nothing new or peculiar is claimed for them. The claim for the second patent mentioned above is based upon the addition of a self-acting pitman, the arrangement of which can be seen in the sketch, and which is more fully illustrated [at Plate LIV, Figs. 1 and 2]. The letter A represents the tank, B the platform of the cart, which is provided with the two wheels, C. These are much smaller than ordinary cart-wheels, in order to give the required number of revolutions necessary to the successful operation of the pump. In order to place the cart-bed at such an elevation as to pass over the rows of plants, it is raised by means of vertical bars, as will be seen in the sketch. One of the wheels, C, has a crank-pin, *c*, attached to it, at a suitable distance from the center, and to this crank-pin is attached the lower end of a pitman, the upper end of which is attached to the pump-lever, G. The discharge-pipe of the pump is provided with a valve to regulate the flow of the liquid. With the transverse pipe before mentioned are connected, by means of screw-joints, branch-pipes, K, which in the sketch and in the diagram are five in number.

"These branch pipes are made of cast metal, and on their inner surface, at the lower end, grooves *l* are formed, either during the process of casting or by planing or cutting them out afterwards. In the lower end of these branch-pipes a plug made of rubber or cork is inserted, and a rod extends from the plug to the upper end of the tube *k*, where it engages with a nut by which the plug may be tightened or loosened. It will be seen that the liquid passing through this pipe must escape by way of the grooves and assume the form of spray, and that by tightening or loosening the plug the size of the grooves is increased or diminished.

"This machine makes a remarkably fine spray, but it possesses the same disadvantage as those already mentioned, namely, the ease with which the nozzles clog, notwithstanding the receiving-pipe of the pump is provided with a strainer. This I found to be a serious drawback, requiring frequent stopping of the driver and his dismounting to remove, cleanse, and readjust the plugs. The addition of the self-acting pitman has proved less useful than one would suppose, for Judge Johnson himself writes me that 'experience has demonstrated the fact that it is about as easy and far more economical to work the pump by hand-power than to use the pitman rod.' By dispensing with it, the tank may be placed on any cart without special construction. This machine has been considerably used, but its price ($65 without the cart) is very high when compared with that of others here described."

In this apparatus any suitable force-pump may be used, and no special pump features are designated for it, except that a "double-acting" one is recommended. The arrangement of the pipe to bear nozzles is essentially the same as may be seen in several later machines, notably in those of Mr. Jones, Mr. Binkley, and Mr. Goodin, as described

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below. As compared with the Johnson machine with its pump motor discarded, these exhibit nothing new of much value. They differ especially in the kinds of nozzles employed, but all use nozzles of old type.

The machine of Mr. C. O. Jones, of Massillon, Ala., is represented in Plate LII. In its arrangement we find one of W. & B. Douglas's force-pumps fixed to a post at one corner of the reservoir. The pump sucks the poisoned liquid from the bottom of a large square tank and delivers it through the main and cross-pipe, which extends 25 feet wide and has short tubular branches bearing nozzles, that discharge the liquid, 40 feet wide, from above and behind the tank. This receptacle is of large size, possessing a contents of 250 gallons. That amount of poison it applies over five or six acres. The weight, of course, is too great for rapid driving, and six mules are used in the field. It also engages much human labor, requiring four men, one to drive, one to use a stirrer in the vat to keep the poison diffused, and two to take turns at pumping. The poisoning is accomplished at a great expenditure of labor, and the method is in no way economical. It is a good example of the old method of broadcast spraying, and shows well the possibility for the spray to blow upon the operators in machines of this type. The pump costs $22, and the rest of the apparatus costs about $50. It is cumbrous and not economic. The illustration given above is from a photograph. On this and some notes made by Mr. W. H. Patton, the above statements are based.

What is said of the two following machines is taken from Professor Riley's Bulletin on the Cotton Worm:

"*The Binkley Atomizer.*—This sprinkler, invented but not patented by Mr. J. N. Binkley, of Columbus, Tex., and herewith illustrated, is one of the simplest and yet one of the best in use. [Fig. 5 of Plate LIV] represents it in operation with a part of the pump. This pump is the usual double-acting force-pump secured to the top of a barrel containing the liquid. The letter *a* represents the pump cylinder, *b* the air chamber, and *c* a transverse tin pipe connected with the discharge pipe of the pump and having four of the atomizing nozzles. [Fig. 1 of Plate XXII] shows a side view of the atomizer on a somewhat larger scale. A conical tin piece, *d*, is soldered to the pipe *c*, having at its end an orifice much larger than the fine perforations of the previous machines described. A circular tin plate, *e*, is soldered to the lower side of the cone, *d*, so that the jet of water, issuing with great force from the orifice, strikes the plate at an obtuse angle and is scattered in very fine and far-reaching spray. The large orifice permits smaller objects to be thrown out with the jet, larger objects being prevented by a strainer from entering the pump, while by a slight bending of the distributing-plate, so as to bring it at more acute angles with the nozzle, the spray may be thrown more and more upward. The whole machine is very light and simple and easily made by any tinsmith at comparatively

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trifling cost. The principal drawback to it as at present constructed by Mr. Binkley is that it is made in one piece, so that in case a larger object obstructs the orifice there is some difficulty in removing the same.

"This defect could be easily remedied by making the cone in two pieces, the nozzle itself to be screwed on to the basal or soldered piece. The plates and the orifices should be thoroughly cleansed and dried after use, in order to prevent rusting. The machine with four spouts, as in the figure, throws the spray over six or seven rows, but its capacity is easily increased by lengthening the transverse pipe (*c*). Its cost is less than $10.

"After witnessing this machine in operation, I am satisfied that the atomizing principle is a most valuable one, and that with modified conducting pipes or tubing, so as to throw the spray from near the ground up into the plants and on the under surface of the leaves, as in Mr. Daughtrey's machine, it will give great satisfaction because of its cheapness and simplicity.

"*The Goodin Sprinkler.*—This machine, invented by Mr. James L. Goodin, of Montgomery, Tex. (patent No. 198014, December 11, 1877), is represented by the accompanying cuts. [Fig. 4 of Plate LIV] is a top view, and Fig. 3 a side view of the same. The letter A represents a tank or any other vessel to receive the poisoned liquid.

"In the lower part of the forward end of the tank, A, is secured a discharge-pipe, B, the inner end of which is provided with a valve or ordinary sirup-faucet. The stem, C, of the valve or faucet passes up through a hole in the top of the tank, A, and its upper end is pivoted to the end of a lever, D, which is pivoted to a short standard, E, attached to the top of the tank, A.

"To the forward end of the pipe, B, is attached a cross-pipe, F, from the forward side of the center and ends of which project short pipes, G, having heads, H, attached to their forward ends. The heads, H, are perforated with numerous small holes. The pipes, B F, are jointed as shown in the drawing, so that they may be lengthened or shortened as circumstances may require."

Wolfram's Machine.—One of the more recent machines is that represented in Plate LI. It is patented, No. 241577, May 17, 1881, by Mr. John A. Wolfram, of Meyersville, De Witt County, Texas. This device is specially interesting as another attempt to poison the under-surfaces of plants, and this is expressed by Mr. Wolfrain as follows: "The object thereof is to construct such machines or devices in a manner as will render them easy of operation, and sprinkle the plants from above, below, or underneath the leaves at one and the same time, thereby touching every portion of the plant and so destroying every insect that may be on it without any unnecessary waste of the poisonous liquid." The constructions and operations of these devices he describes as follows:

"In the accompanying drawings A represents a suitable reservoir or tank for holding the poisonous liquid, said tank being secured in any suitable manner to a carriage or truck, B.

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"To the tank, A, is attached a suitable pump, C, the piston, *a*, thereof having connected to its upper end a link, *b*, which, in turn, is connected to an arm, *c*, pivoted to the upper end of a standard, *d*, rigidly secured to the top of the tank.

"To the outer end of the arm *c* is pivoted a rod, *e*, its lower end being connected to a crank, *f*, which has its bearings in the side of the tank, A, and grooved pulley, D. The crank, *f*, is made to engage with the grooved pulley, D, in such manner as will cause the crank to revolve by the rotation of the pulley. This I accomplish by the employment of the ordinary clutch, *g*, the two sections thereof being made to engage with each other by the lever, *h*, which is connected thereto, or be disengaged when the pump is not required to be operated.

"The grooved pulley, D, is supported by a suitable bracket, *j*, connected to the side of the tank, A, while the lower grooved pulley, E, is rigidly secured to the inner side of the wheel carriage or truck, so that it will revolve with it. A belt or chain, *i*, passes over the two pulleys, D E, by which motion is communicated to the upper pulley when the carriage or truck is in motion.

"Connected to the pump, C, is a horizontal pipe, F, to the end of which are suitable faucets, *k*, to control the flow of liquid to the sprinkling pipes, these faucets being of any suitable construction found best adapted to the purpose.

"To the horizontal pipe, F, is connected a suitable number of pipes, G, extending down near the ground, and provided at their lower ends with rose-heads, H, each of which has removable screw plugs, *l*, to admit of their being cleaned when required. These pipes, G, are connected to the horizontal pipe, F, by unions or coupling sections, or any other desirable means may be employed. The outer pipes, however, I connect to the pipe, F, by the addition of short sections, *m*, of pipe, although I do not desire to confine myself to any special means employed. The pipes, G, are raised to the required height from the ground, and by a suitable lifting device, consisting of the horizontal supporting arm, I, formed in sections and hinged together, so that when opened and extended they form a continuous horizontal arm, against which the pipes, G, rest.

"To the supporting arm, I, is connected a curved rod, *n*, pivoted to the side of the tank, A, and having connected to it a pivoted arm, *o*, to which the operating lever, *h*, is secured, by means of which the supporting arm, I, may be raised or lowered as circumstances require. This supporting arm or carrier, I, has semicircular seats, *p*, to receive the pipes, G, and hold them in an upright position. The object of forming the arm or carrier, I, in sections and hinging them together is to reduce the length of the same, so as to enable the folding of the pipes from both sides of the carriage or truck when not required for use.

"The rose-heads, H, are preferably formed with rows, 1, 2, 3, 4, 5, and 6, extending lengthwise and up the sides of said rose-heads, so that the plants will be sprinkled above and beneath the leaves.

"The unions of the several sections of pipes admit of their being folded conveniently together, so as to admit of their being transported with ease and without incumbrance.

"The machine will sprinkle as many rows of cotton as there are pipes, G, they being the required distance apart to correspond to the distance between the rows, the hinged sections of the supporting arms or carriers being opened and extended in accordance with the number of pipes, G, that are used."

This machine possesses certain points of special interest. The wheeled reservoir and pumping arrangement is strongly similar to what appeared in Mr. Johnson's machine, described above, as shown in Plate LIII and Plate LIV, Figs. 1 and 2. The plan of a main T-pipe, forming extended arms with backward and downward branches for carrying nozzles, is also an old feature, occurring in modified forms

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in the machines of Johnson, Goodin (Plate LIV, Figs. 3 and 4), Daughtrey (Plate XXXVI), and others, but in the special details of this pipe system some few features of interest appear. Aside from the extension of the nozzle branches to near the ground, there is the rotary joint, *k*, allowing the laterally-extending main arms to be folded backwards, and thus to narrow the apparatus for passing through gates, &c., while the whole system of pipes can be tilted up by the operation of a lever to allow all to be carried above stumps or in turning.

New Machine and improved Accessories for Underspraying Cotton.—In this connection should be noticed some machinery specially devised and perfected for applying the poison from below and above. The general plan of the machine is in accordance with Professor Riley's ideas and instructions, but many of the details have been devised and wrought out by myself in carrying on the work. The description of the machine has already appeared as advance matter from this report in the annual report of the United States Entomologist for 1881–'82. It may first be described as represented in Plate XLVI, and the accessories in Plates XLVII, XLIX, and XLVI should be considered in connection with it, as also the results of some experiments made since this was written.[56]

This machine is transported by combination with a wagon or cart or other suitable vehicle, and consists of a skid, bearing a barrel or other poison receptacle, the force-pump and stirrer operated therein, the hose-pipe leading from the pump-spout and communicating with the several branched pipes which terminate in nozzles carried or trailed beneath the plants to deliver the poison spray upward onto the under surfaces of the foliage.

The skid is a simple frame to hold the horizontal barrel from rolling, and consists of two pieces, Fig. 1, *a a*, of wood, about the length of the barrel, and in section about 3 by 4 inches, joined parallel apart from each other by two cleats, *b b*. The inner, upper angles may be cut to match the curve of the barrel, as at *c c*. The barrel being placed upon this frame is next to be filled.

A good device for mixing the poison thoroughly with the water and for filling the barrel is shown in section in Fig. 2. It consists of a large funnel, *u*, that will hold a bucketful, and has cylindrical sides, *g g*, that rest conformant on the barrel. In this is a gauze or finely-perforated diaphragm, or septum, *d*, and a funnel-shaped base, *t t*, with its spout, *p*, inserted through the bung. The Paris green or other powder is to be put in the funnel and to be washed through the fine perforations, by the water which is poured or pumped in through it into the barrel, *k*. Thus no lumps of poison can enter, and the grains of poison being thoroughly wet and separated remain better suspended in the reservoir. Where flour or other adhesive material or diluent of the powder is to be used such ingredients should be washed in first and the poison afterwards. A one-half inch discharge-spout delivers volume enough for an eight-row machine like the one before us.

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From the spout a main pipe or hose communicates to a pipe extending across and above the rows and bearing branches descending in the alternate interspaces between the rows, while each is provided with a fork or pair of arms to supply a pair of rows. In this special form of the machine the main cross-pipe is hinged to the two sides of the body of the wagon, and at one of these junctures is a lever with a ratchet quadrant whereby to elevate the descending pipes with the arms and nozzles when turning, or to surmount stumps or other obstacles, for in this case the descending pipes are inflexible and stiffly attached to the main cross-pipe and the lever, that they may be elevated by depressing the latter, which can be set at any notch desired, so that the arms may be allowed to trail or drag, or may be suspended partly or wholly near the ground or higher to suit the operator.

There are other ways of attaching this apparatus which allow it to conform to the irregularities of the ground more thoroughly and independent of the rocking of the vehicle, but it is unnecessary to describe them in this connection.

The two arms of the main cross-pipe extend in a direct line and have all the joints and segments stiff, while the segments have each a length equal to the width of a pair of row spaces, whereas by another construction set forth in this report the main arms are either partially or wholly flexile in their joints or segments, or both, and they may stand at an angle with each other, or continuously parallel, as desired. In those cases the parts are supported by a bar or frame which may or may not have runners or legged-wheels other than those of another vehicle combined therewith, and the descending branches are also usually made partially or wholly flexile, that they may hang or drag more thoroughly, conformant to the irregularities of the ground and the rows. Similarly the terminal branches on the descending tubes may stand parallel or at an angle with each other and be straight or curved, with or without flexile joints or segments, but the exact construction in the present example is illustrated in Plate XXXIX, Figs. 4 and 5. While some curve seems usually desirable, it may be made either in the descending branch or its fork, or in the terminal arms, or in all these parts.

Referring to Figs. 4 and 5, *t* is the descending pipe, *y* its fork, which may be braced by an additional piece, and this may serve as a weight, *y z*, to hold the fork from being lifted or tilted, or as a slide-plate, *e y*, beneath, to prevent the ground from wearing the parts above it, or again a separate slide-plate or independent weight, freely removable or not, is sometimes combined with the fork [as will be shown in Plate XLIX]. There are also different ways of making the angle-piece, and one of the best is in Fig. 5 of Plate XXXIX, where two curved pieces of tube are cut and matched together so as to form a 3-way fork, the angle, *y*, between the horizontal parts being about 90°, and the elevation of the part, *t*, which is inserted in the descending branch, is about 45° from the horizontal base-plane. Such a fork offers the least possi-

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ble resistance to the fluid forced through it. In the figure the tubular arms, *i i*, are joined to the angle-piece by the flexile sheath couplings, *e e*, having stout wraps. To prevent the joint thus formed from being too flexile, and to give it additional elasticity, a rod of spring metal extends inside. These spring rods cause the arms to spring to the sides of the cotton plants and the fork to swing or close as pressed upon by the row or not, and thereby conform the positions of their terminal nozzles, *n n*, to the variable width or courses of the rows, to apply the same to discharge diagonally, or from the center of each plant, upward into its foliage.

The nozzles may be joined inflexibly or by an elastic union with sheath and spring rod, or in any of the flexile parts named spring-lined suction-hose or a torsion spring, to allow partial but not complete rotary movement, may be employed. Each terminal arm forms a supply tube to its nozzle chamber, which has an eccentric inlet-passage, from the same tangentially through its wall, admitting the fluid so eccentrically that it whirls in the chamber and discharges through a side outlet in the form of a spray. The whirl thus produced is very intense and gives the fluid such centrifugal motion as will disperse it broadly from the orifice and thus produce a very finely-atomized spray. The spraying power varies with certain details in the proportions and construction of the passages and other parts. With a suitable straining device in the base of the pump, bodies large enough to clog the small outlet cannot enter, but, should clogging materials enter otherwise to interfere with the discharge, the face and back of the chamber may be easily taken apart to remove matters from the interior. The nozzles project so little beyond the supply-pipe as hardly to catch upon the plants, and in case any objection be raised to the slight recess sometimes occurring between the chamber and its pipe, that may be filled completely by metal. This same nozzle is used with equally good effect on other pipes, hydronettes, syringes, or pumps, as well as on blast atomizers, and is unsurpassed for spraying diagonally or upward, as here desired.

The final peculiarities of the nozzles and distributing parts of the machine just described have been attained in the course of extended experimentation in my work under Professor Riley, and I have combined them with each other, with various forcing media, and with means of support and conveyance in some of the ways which seemed to me practical. Before noticing other examples of their application it will be well to consider their internal anatomy more carefully here. For this purpose attention may be directed to Plate XLIX, Figs. 2 to 7. Plate XXXIX, Fig. 4, illustrates the form of fork used in the compound machines represented in the plates cited, while Plate LXIX, Figs. 2 to 7 present several modifications of the fork and its parts as planned and tested by myself.

Referring to the figures cited the parts may be explained as follows: *h* is the coupling or segment of hose or other suitable material, and *t* is

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the main pipe ofthe Y-fork. This main may be of any practical length as a pipe, or can be short enough to be regarded only as a coupling part. The angle coupling-piece proper, indicated by *y*, can be variously made. For example, a solid piece may be bored with three converging intercepting holes, or these passages can be cored out in a casting. The piece may have any suitable form or weight. It should be rounded in front and rather smooth in order not to catch or hang upon vines or other bodies, and it may have a basal lobe extending back beneath or to the sides to prevent injuries to the parts, *e j y*. These parts, as a rule, are not necessarily to be protected. But I have sometimes added a thin sheet-metal plate with more or less up-turned sides, while it is firmly attached or hung loose, as in Plate XXXIX, Fig. 3 *e j*. Coupling-nibs, *t j j*, are screwed or sweated into the angle-piece, *y*. I also have planned other fork constructions, and one is shown in Plate XXXIX, Fig. 5. This style works excellently, and probably offers about the least resistance possible to the inside current. It consists of two curved tubes, *j j*, cut and matched together as shown, one-half being cut from one end of each and the two half ends are united side to side to form the single entrance to the two diverging parts. Such a fork is both strong and light. In the angle *y* can be inserted a filling or brace to increase its strength. Probably the easiest way of joining tubes to form the angle-piece is that shown in Plate XLIX, Fig. 4, as a simple right angle T-tube. In this *e* represents the sheath-couplings of rubber hose. When this method of coupling is used the ends of the tubes should be slightly flared or grooved or annulated on the outside to keep the hose and wire wraps from being pulled off. When desired metallic joints can be made at these places. Such are shown in combination with the reverberatory chamber-fork in Plate XLIX, Fig. 3, where the outside flange of the end of the arm-piece is clamped against the center-piece (or an intermediate packing-ring) by the inside flange of the nut. This gives the joint freedom of rotation. The other essential parts of this figure need no further explanation here. The central chamber there appearing is of more special value as an equalizer in distributing blasts laden with powders or liquids.

The pair of arm-tubes, *e i n*, may extend from their focus, forming T-pipe branches, or they may be set at any suitable angle with each other or with their main as Y-pipe branches, and they can have any length that is practical. These branches may be entirely stiff, or partly or entirely flexible or elastic. When stiff, if continued straight throughout their length, the distal portions especially will be liable to catch upon obstacles and upon the plants, to injure the latter or cause the pipes themselves to be damaged by breakage or bending. To prevent these lateral branches from mutilation or mutilating I have generally directed them wholly, or at least their distal portions, in a somewhat backward manner. Such a stiff form is shown in Plate XLIX, Fig. 6, where each arm has a regular backward curve. The arms are joined by a regular T-

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coupling, and are entirely stiff throughout. The branch, *h t*, may also be stiff, but in case the arms are rigid it will generally be preferable that this main be flexible throughout, or at least in one of its junctures, *h*. Any or all of the three tubes forming the fork may be made entirely elastic by using hose-tubing with coiled or straight springs on the outside or the inside of the same. A straight piece of spring metal is generally preferable from being simpler and cheaper. In case any peculiar curve or position is to be given to the hose-tubes it may similarly be done by a rod having elastic or inelastic properties. To prevent such a rod from sliding out of its proper position in the tube it should be secured in at least one point. In Plate XLIX Fig. 5 is a sectional view of a fork showing how the rod may be inserted and fastened; *t* is the insertion of the main, and *j* represents the arms or their coupling-pieces, while *y* is the angle coupling. The rods to extend into the branches are indicated by *s c*. In this case they are shown with the one end *s* free while the two cross in the angle, and each has its other end riveted or soldered at *c*, in a hole drilled through the walls of the passage. Where the central piece is a casting this method is sometimes the best, but in Plate XXXIX, Fig. 4, a single rod, represented by the broken line *s s*, extends around through both arms acting as a V-spring. Where the middle coupling is made by joining pieces of pipe [*Ib.*, Fig. 5.], a rod of such shape is easily inserted before the parts are united. Other variations in the construction of these same devices can be thought out by any practical mechanic, and hence such need not be described here. When long sections of hose are used, where they tend to sag, bend, or kink as along the more or less horizontal supporting bar or frame, or in the nozzle-bearing arms, inside rods should be inserted as supports. They are also of value to hold hose sections at any particular curve desired. The flexible sections or joint-sheaths, *e e*, are easily made by any planter and require no special mechanical skill. The hose segment should fit tight upon the metal one and be held firmer by a single band or wire wrap, *o*, twisted or clinched tight around it. The flexibility of hose-coupled joints allows no breakage of the pipes, by permitting only tensile strain without lateral strain, rendering repair seldom necessary, whereas with stiff joints the segments are very liable to bend or break, especially at their ends, where weakened by the thread cut for insertion in the screw-couplings. Stiff systems require the pipe to be several times heavier to prevent bending and breakage. Thus, aside from the economy in having much less weight, the lighter tubing costs less; and this reduction in weight and price allows the use of brass tubes, which are much preferable to heavy iron pipes that rust and are otherwise objectionable. Also, on this plan, even light zinc, tin, or other sheet-metal sections or angle-pieces which are not soldered stiffly together, but are easily separated or joined by any planter, can be employed. The lightest and cheapest apparatus can be made in these ways, and with the least amount of labor and skill in construct-

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ing or repairing them. It was for these reasons that I first used flexile systems of tubes and cheap apparatuses to be tested. When they trail upon the ground they are not affected by its irregularities, nor do they catch upon the plants to receive or give injury, but conform easily to all changes of the ground or the rows. In turning in the cotton the hanging flexile forks drag through among the plants, and when the apparatus is turned short on only two wheels so that one of its sides swings somewhat backwards while the other goes around, or when the machine is backed by any accidental or intentional movement of the horses in the cotton, the forks are not pushed into or against the plants in the injurious manner which might result were the stem and branch pipes entirely stiff; but in such cases the pliable pipes bend while the lower part of the fork does not move or else is dragged backward with no possible harm. But in order that the wheels in turning do not run onto the fork-arms if lying on the ground, these must be suspended from safe points either before or behind the wheel, or at such a distance to one side from the wheel that it cannot be turned forward or backward to roll upon the arms. The peculiar disposition of the parts in the A-frame machines shown in the plates is such as to insure safety in these respects. It should also be added that block-tin pipes and copper or lead tubes are valuable on account of their being less subject to corrosion, but the softness or pliability of these metals allows such tubes to bend easily, hence, where employed, they should be attached at short intervals upon some rigid support or have a stiff internal rod such as I have introduced in hose to maintain it in such direction, course, or position as may be wished. Zinc does not rust, but is most easily corroded by anything of an acid nature. It will generally be preferred to common tin, but is somewhat softer and breaks more easily. Such pipe systems can be used with any kind of poison receptacle or with any forcing medium, such as a force-pump, bellows, gas-pressure generator, or a gravitating column of liquid.

For pipe-systems of stiff, flexible, or flexible-jointed tubing, embracing forks of the kinds just described, to be carried or trailed through the field, I have combined groups of various sizes, including two or more of the forks, and some different means of support and conveyance of the same need to be considered here. The old-fashioned way of giving support to the primary or main trunk-branches of tubes by attaching them to the rear horizontal parts of any suitable vehicle, to some frame, bar, or box upon the same, is naturally the simplest; but adjustability to suit row-spaces of different widths is desired, and different arrangements with these should be adopted. As illustrating this topic the following machine should be noticed. This machine was planned by me and tested to show a possible adjustability and the possible width that might be embraced in one of these machines. Plate XLVII exhibits a rear view of this apparatus as cut from a photograph of it taken to show its operation in the field. The cotton being unusually small and

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partly stripped the machine is much less concealed than it would be had a field of larger cotton been selected. The ground plan of the frame and system of pipes is diagramatically illustrated in Plate XLIX in Fig. 1, while the same device as folded narrow to be hauled through gat s, &c., is cut from a photograph as seen in Plate XLVIII. By reference to the diagram the frame, *a x l z*, is seen to be A-shaped, and is composed of two main bars, *a*, hinged together by a bolt, at *o*, extended by two long arms, *x l*, spliced on, at *x*, while a cross-piece, *z z*, is bolted on as a set-bar upon which the side bars can be set at a wider or lesser angle. Numerous holes for this purpose will be seen in the cross-bar. This cross piece is also cut and spliced at its middle so that its one half can lap against the side of the other when the frame is narrowed. Beneath the side bars, near their middle, legged wheels are attached.

These appear best in Plate XLVIII. The crank-axle of the wheel has a round, upturned pivot inserted in the base of the vertical leg which is tubular, being a piece of heavy gas-pipe with a solid T-plate welded in the top and bolted to the frame. The crank-axle also has attached to it by a band clamp a stout brace extending upward and forward to the cross-bar. The pivot arrangement allows the wheel to be set parallel to the rows after being thrown out of parallelism by setting the side bars closer or farther from each other. The legs described elsewhere, and shown in the machine figured in Plate L, are likewise adjustable on a vertical pivot and answer the same purpose, while they are simple, strong, and on some accounts preferable to those here used. They may be employed on the A-frame instead of these. The frame is thus supported at its sides near the middle, so nearly all of its weight comes on the two wheels; but its forward half is the heavier, and this is sustained and the whole is drawn by the apex-attachment to the hind end of the body of a wagon. This frame should be hinged fast, preferably near one corner of the body and at a point over the center of the row interspaces. This can be done in various ways, but a movement up and down as well as laterally and some degree of rocking should be allowed at this joint between the wagon and the frame. It can be linked by a clevis or otherwise to the eye of the end-gate rod; but a stronger fastening consists of a thick block 4½ by 4½ inches a little longer than the width of the box, but with its ends halved out to allow it to drop snugly half way in and hang close against the end-gate, against which it is pulled by the frame which has a pivot or bolt inserted through its front end and through one end of the block. By this arrangement the strain upon the end-gate is somewhat equalized, and the whole is easily detached, for at this connection the wagon should be conveniently separated whenever it is to be driven off for a fresh supply of water.

In Plate XLIX, Fig. 1, the system of pipe-branches appears separated slightly from the side bars to which its main branches are normally at-

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tached, and is designated by the letters *o w v c t*, &c. The Y-forks, *t y n*, are the same as have been described. Each of these is joined, at *v*, to a side branch of the pipe on the side-bar. Such a branch is shown at *v b*, Plate XLIX, Fig. 8. This branch is preferably made of a piece of tube cut very diagonal and sweated on over a hole in the arm-pipe. The diagonal cut gives it a much longer attachment, and the acute angle can be more easily filled or braced, at *v*, than could a right angle. Even where a right-angled fork is desired it had better be formed in this way and then have a curve to bring its distal parts to a right-angled direction. The straight part shown in Fig. 8 can be very short, and thus have only the length of a coupling, or it may extend as an entire long section reaching to the next branch. In the latter case the machine will embrace fewer pieces and be simpler in construction. The sections of pipe upon the frame are preferably joined together by sheath-couplings of hose with single wraps of wire or metal bands. The main branch, *o*, of this pipe-system is connected by a hose to the spout of a force-pump, operated as in Plates XLVI and XLVII. Any suitable force-pump may be used; but that described (p. 282) and illustrated (Plate XLVI) is probably the best.

This machine is probably the broadest one ever put on wheels. It poisons sixteen rows at one time, a strip about 60 feet or 20 yards wide. Yet the whole concern is light, and as I tested it in the cotton, the pulling was easy work for two horses. This is about the maximum size that can be used practically, and experience may demonstrate that it is better to use a narrower, more wieldy machine and drive at greater speed. One of the smallest force-pumps of the trade with a $\frac{3}{4}$-inch or $\frac{5}{8}$-inch spout supplies it with sufficient liquid and pressure without being tiresome work for one man, and with my nozzles it required only 10 to 15 gallons to poison an acre, whereas, before their introduction, 40 gallons or more were required. By these devices the poison can be more evenly and sparsely diffused, and one-third the amount of poison thus applied will be equally as effective as the whole amount administered with the other devices now known. With large cotton more poison and more water should be distributed, so the amount of water with these nozzles will probably vary from 10 to 25 gallons per acre, and the poison in proportion. After the pipes are once cleared of rubbish, the strainer on the pump prevents clogging material from reaching the nozzles and there is comparatively little difficulty from choking of the outlets. When this does occur each nozzle is readily opened to remove any obstructing object. At the outset it is desirable to pump very rapidly until the pipes are filled, all the air is out, and a good pressure established equally upon all the jets; then the spray will be discharged regularly, filling the rows with a very fine mist, which poisons all surfaces of the plant but especially the under-surfaces, where the poison will be practically permanent to destroy existing worms or prevent others thereafter.

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Machines of the above description but of smaller size do not need the legged wheels, but are mounted entirely upon the cart or wagon in which case the cross-bar of the frame rests upon the rear part of the vehicle, and the front angle of the frame is attached farther forward; but where extremest width is aimed at wheels so close together as those of a wagon are objectionable, since their lateral rocking on passing upon the row-ridges or other irregularities would cause the long arms to be thrown alternately up and down to an undesirable extent. This can be somewhat obviated by directing the arms somewhat upward, but where greatest expanse is sought wheels farther apart to straddle two or more rows will remedy the fault just mentioned. As a rule, smaller machines will probably be used to avoid the extra expense of special wheels and legs. And where cotton is uniformly planted, or the adjustability is not aimed at, the cross-bar alone, in its simplest form, or a pair of the long arms spliced together to extend straight across and far off from the vehicle, will, of course, be sufficient with any forms of ordinary jointed tubes. Yet there are practical plans for altering the pipes on the straight cross-bar to suit row-spaces of diverse widths. The *first* is, to have no intermediate segments joining the pipes but have them all radiate from a central source to the bar, on which they are adjustably fixed by screw-clamps, hooks, or otherwise, and from which they continue parallel onward to their juncture with the distal arms. This makes a pipe-system of the smallest number of pieces, but it takes more of the tubing than does the segmental construction. *Secondly*, the method of employing segments which are adjustable in length can be resorted to.

The patterns I have made for this arrangement are represented in Plate XLIX, Figs. 9 and 10. We may first consider that shown in Fig. 9. The metal part with its side branch is indicated by *m b*. The other half of the segment is a piece of hose, *h*, clamped to the metal parts by wire wraps, *o*, at its ends. It will be seen that the metal part telescopes deeply into the hose and the two tubes thus overlap concentrically so far that there is a wide range for the adjustment of the one upon the other in a back and forth direction to set the section thus formed wider or shorter as may be required. As already stated above, the hose piece may have inside itself a small rod to give it support. The same effect is also accomplished by the design in Plate XLIX, Fig. 10, where *m b* is a smaller half of the segment telescoped into *m*, the larger half, and at *h* is a sheath-coupling wired to both at *oo*. The former of the two plans gives a simpler and lighter set of tubing. The lightest set of tubes and simplest to make is where only hose is used for the segments and all parts except the angle-couplings and nozzles, while the flexible parts are sustained by tension or by small rods inside. The cost of materials for sets of this kind is not greater than for brass tubing, though less durable. Also the cost of making is not so great with the rubber; and then any planter can

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repair the machine or put it together without engaging a plumber. And this is a weighty reason why hose-couplings only should be employed in all tubing that must be manipulated by those who are not plumbers. The principles here set forth will also find application in many other machines.

Another method of setting the system of nozzles wider apart or nearer together to suit fields having rows of different widths is the simplest, as effected by the A-frames. In these it is only necessary to shift one bolt on the cross-bar and all the branches at once are thereby approximated or separated to suit narrower or wider rows without necessitating the alterations of any pipe-joint. The dichotomous system of pipes thus adjusted upon any suitable conveyance gives excellent satisfaction and is employable with any suitable forcing medium, for bellows, gravitation, pumps, and gas generators have been utilized by me in testing these systems. The engagement of gravitation in this connection will next be considered.

VI. GRAVITATIONAL DISTRIBUTORS.

FOR LIQUID POISON.

In these only the weight of the liquid or the gravitational force is engaged for spraying or sprinkling. The devices under this heading may be classed as, 1, Wheeled, 2, Horse-back, 3, Knapsack, and, 4, Hand automatic sprinklers.

WHEELED AUTOMATIC SPRINKLERS.—Closely related to the foregoing apparatuses is another appearing in Plate L. This I have called *The Tripod Automatic Sprinkler*. The frame is triangular upon legged-wheels at its corners, its two lateral corners with extension-arms spliced upon the cross-piece and not radially placed, while its front is provided with shafts, and on top is mounted a tripod with a windlass, pulley, and rope for lifting and holding suspended at a considerable height the barrel of poison as shown. The whole poisons twelve rows at one time, or a strip about 40 feet wide. It is drawn easily by a single mule and requires but one man, the driver, to operate it. He rides upon a seat near the front and can work the windlass to lift the poison from the ground to such a height that gravitation gives the pressure for squirting. The legs are arches (of iron ¾ inch by 3 inches thick) pivoted to the frame and clamped to it by nuts upon their bolts (1 inch thick) at the top. Through the lower extremity of the forked legs is the iron bolt, which serves as the axle of the wheel. Common wagon or cart wheels, having the hub filled with a tight plug perforated by an axial hole suited to turn, or turn upon, the iron bolt, answer for use in the legs, saving the expense of making special ones at much cost for the machine. The top pivots of the leg-arches also bolt the rear cross-bar, and the two diagonal bars and these parts with the wheels also may be set wider or narrower to other holes in the cross-bar. The

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latter also has a median splice, which may be separated to allow one of its halves to fold against the side of its other when the machine is to be made very narrow for hauling through gates, &c. For this purpose also the extension-arms at the sides and spliced to either of the ends of the diagonal bars, or the cross-bar may be turned forward to lie parallel to the diagonal pieces, and the barrel should be lowered. The rear tripod-legs close also, for they are joined to the frame by hinges. The wheels should not be set too close together, else the high tripod may tip over in driving upon the row ridges or other obstacles. The shafts are hinged to arms upon the front leg, and this with the wheel can turn easily at the top upon the pivot which is loose in the arch, but has a collar clamped tight to the frame. The front leg of the tripod has foot-pins by which to ascend to the pulley at the top. The windlass is of iron with a cylinder about 1½ inches in diameter and a crank 18 inches long. This has a stop-button on the front tripod-leg, which also supports the windlass. Two small two-wheeled pulleys are used with a rope three-fourths of an inch thick. Its end is provided with a pair of barrel-hooks, which clutch the chimbs. A full-sized barrel of poisoned water is raised by one hand, but it is rather hard straining unless gears be added to give better leverage. A small half-barrel, wine or beer keg that will hold from 10 to 20 gallons is much preferable. With the barrel 10 to 12 feet high pressure enough to sprinkle ordinary cotton from beneath is secured, and with my cyclone nozzles it applies 10 to 15 gallons to the acre. The machine does not thus give as much pressure as would a force-pump, and hence the spray is much coarser. When desired, a small force-pump is secured to the frame and may be worked with one hand or a treadle, or a rachet lever playing upon the spokes or upon lugs attached to the fellies or rim of the wheel. If the barrel is not carried low upon the frame, the pump should be attached upside down. The arrangement of the pipes is on essentially the same plan as has already been described. The wheels being far apart and at the three angles of a triangular frame it conforms excellently to all undulations of the ground and has a broad base to support the barrel, which is situated as within the apex of a pyramid. The frame can be made and put together easily. This machine, whether operated automatically or by a pump, is a practical device, and where wagon wheels are used it will not prove high priced.

"*The Schanck Sprinkler.*—This sprinkler, invented by Mr. Lafayette S. Schanck, of Marlborough, N. J. (patent No. 215683, May 20, 1869), consists of the barrel with a stirring apparatus and with two or more pipes connected with the bottom of the barrel, each having a finely-perforated nozzle. The whole apparatus is placed on a cart.

"*The Taylor Sprinkler.*—The sprinkling apparatus of the Taylor dusting and sprinkling machine should be mentioned in this connection. Plate LVI, Fig. 4, gives a representation of this machine, but with the dusting arrangement detached. Leaving out those parts that

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have been already described, this sprinkling apparatus may be explained as follows:

"The letter I represents a metal strap, attached to the rear bar of the frame, G, with the end parts bent forward at right angles and with holes to receive the journals of the cylinder, H, the arms of the strap thus serving as springs to keep the cylinder in place. By a simple arrangement, indicated in the figure, the frame, G, may be adjusted higher or lower to the standards, D, according to the height of the plants. In the upper side of the cylinder, H, are formed a number of small holes, through which the liquid poison escapes to the plants. In the center of the perforated side of the cylinder, H, is formed a hole in which is secured the tube, J, through which the poison is poured into the said cylinder. The inner end of tube, J, is soldered in part to the inner surface of the opposite side of the cylinder, H, to prevent it from being loosened by the pressure of the liquid. In the sides of the inner end of the tube, J, are formed holes of such a size that the liquid will readily pass out of the said tube into the cylinder, H. To the rear side of cylinder, H, are attached loops, K, to which are attached cords, L, which pass through eyes, M, or around pulleys attached to the rear bar of the frame, G. From the eyes or pulleys, M, the cords, L, pass over the cylinder, H, and are attached to the projecting end of the tube, J. The cords, L, serve to secure the cylinder, H, in place and limit its movement when turned upon its journals. One or more balls, N, may be placed in the cylinder, H, which, when the cylinder becomes empty, make a noise, and thus notify the operator.

"If desired, the cylinder, H, may be rigidly secured to a single bar, G, attached to a single standard, D. In this case holes must be formed also in the upper side of the cylinder, H. The holes in the upper side let the air escape in filling, and admit air to cause the liquid poison to flow out through the lower holes. This construction is a little simpler and cheaper than the other, but causes a slight waste of the poison, as some of the poison will flow out through the lower holes while the cylinder is being filled.

"The operator may be protected from the poisonous liquid by cloth screens placed upon the opposite sides of the handles, B, and attached at their upper and lower edges to two pairs of rearwardly projecting bars attached to the frame-work of the machine.

"The sprinkling apparatus mentioned in connection with the Robinson Dusting and Sprinkling machine, described on page —, consists of a tank, B, for holding the liquid, and of a sprinkling tube, C, connected with the tank and extending across the frame and beyond far enough to reach the two outside rows. This tube has small perforations, D, at the ends, and also at the middle, E, for sprinkling the liquid upon three rows of cotton. A gate or valve, F, is arranged in the tank to shut off the liquid from the tube or to regulate the discharge. The end of the tube is to be closed with a cap or plug, so that it can be opened and the perforations be cleaned out."

Suction Force-pumps and Windlass Elevators, for filling large elevated tanks or raising them, belong very properly to the subject of wheeled-sprinklers, but cannot be entered upon in detail at present. Barrels of liquid can be loaded onto vehicles by the usual methods of rolling them up an inclined supports, &c., also they may be elevated by pulley, windlass, or derrick arrangements; but in many instances, especially where the water is to be taken from a creek or other body of water to the brink of which the conveyance may be brought, it is most convenient to pump

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the water directly up into the reservoir, which is already mounted, and for this purpose the common sheet-metal "*Bilge Pumps*," used for pumping out ships and cellars, are cheapest and effectual.

Concerning the small hand-machines, knapsack and horseback apparatuses for sprinkling liquid by gravitational pressure very little need be added above what has already appeared in the earlier reports.

HORSEBACK AUTOMATIC SPRINKLERS.—To lessen the limb-labor in carrying hand-sprinklers or knapsack reservoirs it is preferable to mount on horseback with such vessels. This may be done with all kinds, even with common watering-pots. The watering pots and cans are carried thus most commonly where they are extensively used for poisoning Cotton Worms as obtains especially on the Mississippi of Louisana, Yazoo, and southern Arkansas. The cotton grows so high that the hand pots could not well be carried high enough except by being mounted. The mules accustomed to tilling the crops will walk between a pair of rows without being guided, hence the rider takes one pot in each hand, poisoning two rows at once. At short intervals he shakes the pot to prevent the poison from separating entirely from the water. This is commonly neglected, and usually the "darkie" who is intrusted with this work does not know or care whether it is mixed or not, whether the nozzle is mostly clogged, or if the spray is directed accurately upon the plants or largely between the rows. The cotton I have seen being poisoned throughout those regions was almost invariably treated very imperfectly, often in such a careless way as not to protect the plants from being stripped. When the pots are empty the rider exchanges them for others which are kept filled by men stationed at mixing-barrels which are commonly at both ends of the rows, or at long intervals in the rows. Sometimes the buckets are carried on a yoke-bar across the shoulders, and something of the kind is a necessity where the rows are wide apart. The bar is commonly carried across the shoulders, but may be supported upon the horn of the saddle, or otherwise upon the horse alone. A method rarely employed is the following: On either side of the horse is a pole having its lower end attached to the lower part of a girth around the horse. The upper end of the pole or bar has a fork supporting the weight of a watering pot, while the whole is sustained from falling by the hand of the same side grasping the handle of the pot, which can so be tilted at will. Almost all the single knapsack cans and hand-sprinklers are susceptible of being joined in pairs to hang one on each side of a horse.

The following description of the Willie Horseback Sprinkler, from the Department Report on Cotton Insects (p. 248), will illustrate this subject more fully.

"*The Willie Horseback Sprinkler.*—Another machine has been invented for distributing liquid poisons upon cotton, by Mr. William T. Willie, of Brenham, Tex.; patent No. 158345, dated December 29, 1874. It consists of a frame which may be rigidly secured to a saddle, in a transverse position, there being cans for holding the liquid and pro-

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vided with distributing faucets arranged upon both ends of the frame, the one balancing the other, and one or both at the same time may be operated by the rider.

"In Plate LVI, Fig. 1, in the cut is an end view of the machine; Fig. 2 is a plane view, and Fig. 3 is a side view of the same.

"A A' designate, respectively, the front and rear bars of the frame, connected together on each side by means of a platform, C, upon which are to be placed oil-cans, B, or other convenient vessels for the reception of the destroying compounds. These vessels are removably secured thereto in any suitable manner, and their outer lateral edges are each provided with a distributing stop-cock, D, having a crescent-shaped perforated nozzle-piece, *d*, by means of which the liquid poison will be shed over a wide space. The front bar, A, has an angular notch, E, cut into its lower edge, near the apex of which, and one each side thereof, perforations, *e*, are made by means of which it is secured to the pommel of the saddle. It is also provided with perforations. *e'*, upon its lower edge, by means of which it is laterally stayed by a rope passing thence to the girth-rings on each side of the saddle. The rear bar, A', is in like manner notched as shown in Fig. 2, and is provided with a slot, *f*, at the apex of its notch, by means of which it is strapped to the cantle of a saddle, and with perforations, *f'*, along its lower edge, serving as a means of attachment for a rope, passing thence to the girth-rings on each side.

"It will be seen from the above description that the frame is firmly attached both to the pommel and cantle of the saddle, and that it is braced and steadied to resist displacement by ropes or straps leading from the perforations, *e'* and *f'*, upon the front and rear bars of the frame, respectively, to the girth-rings on each side of the saddle, constituting a simple, convenient, and effectual attachment for the purpose of preventing any displacement. The notches of the front and rear bars, A A', are intended to be straddled over that portion of the pad-frame of a saddle which projects in front of the pommel thereof, and extends in rear of the cantle, the rider being seated between the two, with a poison-receptacle on each side, with their stop-cocks within easy reach of his hand. He can thus accurately regulate the flow of poison according to the amount required to effect the purpose, the movement of the horse serving materially to assist the distribution.

"*The Ramsey Sprinkler.*—Mr. Croghan A. Ramsey, of Schulenburg, Tex., has obtained a patent (No. 163526, May 18, 1875) for the very simple contrivance which is illustrated in Plate LVI, Fig. 5. It consists of a box or vessel, A, large enough to hold about five gallons. It is provided at its top with a receiving funnel, *a*, for the liquid. At the bottom or on the front side near the bottom, and near each end, are two flexible tubes or rubber hose, B, provided with nozzles, *b*. This device is intended to be strapped upon a horse's back, to the cantle of a saddle, with the tubes in front. The front of the vessel, A, is inclined backward, so as not to interfere with the movements of the rider; and a pad, C, may be placed under it, so as to cause it to rest easy upon the horse. The nozzles, when not in use, are held above the top of the box by means of hooks, *c*, which seize over rings, *d*, upon the top corners of the box, so as to prevent the liquid from flowing out. When in use the rider takes a tube in each hand and proceeds to sprinkle the rows on each side.

KNAPSACK AUTOMATIC SPRINKLERS.—A number of these have been in use, and the following examples from the first edition of this work illustrates these devices sufficiently:

"*The Gray Sprinkler.*—Constructed by Mr. Frank M. Gray of Jeffer-

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son, Ill. (Plate LVI, Fig. 6), consists of a can, capable of holding about eight gallons of liquid, and so formed as to rest easy on the back, to which it is fastened, knapsack-fashion, by adjustable straps, which reach over the shoulders and fasten across the breast. To the lower part of the can are attached two rubber tubes, which are connected with two nozzles or sprinklers. The inside of the can has three shelves, which help to keep the mixture stirred. There is a convenient lever at the bottom which presses the tubes and shuts off the outflow at will, and two hooks on the sides near the top, on which to hang the tubes when not in use. On the top is a small air tube and a capped orifice.

"*The Ruggles Sprinkler.*—Invented by Mr. Silas Ruggles, of Three Rivers, Mass. (patent No. 203072, April 30, 1878), is an exact counterpart of Gray's Sprinkler, with the addition of a stirrer, agitated by the movement of the arm of the bearer.

"*The Townsend Sprinkler.*—This was invented by Mr. George Townsend, of Greenville Centre, N. Y. (patent No. 212412, February 18, 1879) and is intended, like Gray's Sprinkler, to be carried on the back of a person. It consists of a tank with a stirring arrangement, but has only one sprinkling tube, and sprinkles, therefore, only one row of plants."

It is illustrated in Plate LV, Figs. 3 and 4. L is one of the shoulder loops for suspending it. The can is shown in mesial section in Fig. 4, while all of its interior appears in Fig. 3. D is the lid. The dashes E E, are moved up and down with the rod, D F, by the handle, F. The lever, T, is worked by a string to the hand and opens the valve, N, against the spring, P, to free the liquid through a pipe, G H I, terminating in the nozzle, K, by which the spray is directed.

AUTOMATIC HAND-SPRINKLERS.—Under this section come naturally the ordinary watering-pots or garden-sprinklers with which all are so familiar that descriptions seem unnecessary. Many variations on the standard watering-pot have been patented, but they seldom if ever appear in the trade. The use of automatic hand-sprinklers upon horseback has been described on page 300, and the kinds of many punctured nozzles preferable for employment on them are discussed in the chapter on nozzles. Here it should be added that the sprinkler illustrated in Plate LV, Figs. 1 and 2, and described on page 273, answers well as an automatic hand-sprinkler, usable instead of the watering pots, and generally preferable. When the basal valve is held open the spray descends direct from the base. The valve may be held up mechanically by adding a hook or loop from the bail to the valve-stem, and this is more convenient than to be constantly tipping the common sprinkler.

FOR DRY POISON; SIFTERS.

Here will be included the various sieve-machines or sifters, and they may be grouped as (1) Reciprocating-sieve Machines; (2) Rotary-sieve Machines; (3) Reciprocating-stirrer sifters, and (3) Rotary-stirrer Sifters.

The sifters are probably the worst machines for distributing dry

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poison. With most of them there is the difficulty that they clog or do not sift regularly, especially when they are affected with wetness, which will generally occur, for the best time to apply the dry poison is when the foliage is damp enough to make it adhere. Also the adhesive diluents, as flour, &c., which it is advisable to add to the poison increase the clogging much under the influence of moisture. On the other hand, when there is dryness there generally exists a little wind which prevents the fine powder from gravitating regularly from the sieve to the plants. The powder is better thrown by some device that will give it considerable impetus, and on this account the centrifugal force from whirling-brushes or the blast from a bellows or pump or rotary fan-blower is preferable. Such impetus will make it penetrate more firmly into the rough surfaces of the foliage or into the moisture upon the plants, and, to some extent, resist moderate breezes. The operation of the latter machines is also less affected by moisture. Although sifters may not be recommended generally, it is necessary to notice briefly what has been done toward the application of sieves to the purposes of poisoning.

With sifters there is also probably more danger of the laborer getting poisoned than with machines of any other class. Where a blast or squirting power is used the poison can be directed away from the operator with some force, or be discharged from a pipe extending to a safe distance from him, but with sifters the fine powder follows the caprices of the wind, and even with a gentle breeze there constantly exists on the leeward side of a person a varying weak whirlwind, but one which is strong enough to lift some of the poison to his face and cause it to be inhaled. It was probably on account of this difficulty that Mr. J. W. Young patented, in combination with his machine described below, a screen to come between the sifter and the person using it.

RECIPROCATING-SIEVE MACHINES.—With these the sieve itself is operated by a back-and-forth movement.

Concerning the method of poisoning with the simplest hand-sifters, Mr. William Trelease has reported as follows in the Department Report on Cotton Insects (p. 221):

"My dry poisons were applied by a sieve made of a 2-quart tin bucket, the bottom of which was replaced by perforated tin, and which was provided with a socket at the side for the insertion of a wooden handle about 3 feet long.

"My experiments with dry poisons were not extensive enough for me to determine accurately the amount of labor required to poison an acre; but Mr. Lide, the manager of George O. Baker's plantation at Selma, Ala., tells me that a hand can poison from 1 to 2 acres of cotton per day. He tells me, further, that one barrel of Royall's mixture goes over about 3 acres."

Thus it is seen that the work with such a tool is very slow, and can only be admissible for very small patches or in an emergency where better means are not obtainable.

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"The usual way of applying dry poison is to sift it over the leaves by means of an ordinary bread-sieve firmly attached to a handle 3 or 4 feet long. One or two layers of muslin should be placed in the bottom of the sieve to prevent a too rapid escape of the powder. With some practice in handling these sieves the foliage of the plants can be pretty evenly dusted, but in general there is considerable waste of the poison by this method. One man can go over 1 acre per day, but if the plants are high enough, and the soil not too much softened by rains, the poison can be sifted by men on horseback. This secures a more even movement, and consequently less waste of material. Some have tried, with advantage, to dust two adjacent rows at once by means of a stick of suitable length with a sieve fastened to each end, the operator riding between the rows and tapping the stick gently, either with his hand or another stick.

"An old sack, such as those used for table salt, will do good service attached to the end of a stick, but the safest thing for use on a small scale is a perforated tin box (Plate LVII, Fig. 7), with a double lid (for security when not in use), and having a handle 3 or 4 feet long. By taking the handle of the dust-box in the left hand, and tapping the box with a stick held in the right, the poison may be rapidly and evenly distributed, not only on the upper surfaces of the leaves, but on the under sides as well, if the box is held within and among the plants.

"A number of patents have been taken out for machines for dusting the plants with poison, but for some reason or other none have become popular, and I have not been able to learn that any of them are in use at the present time. The object of these machines is to distribute the poison more economically and rapidly than it is done by the simple sifting method here mentioned. The reason of their not becoming popular is, perhaps, that they do not accomplish their object. The gain in the more economic use of the powder is not large enough to induce the planters to invest in them, especially where labor is cheap, as the employment of an additional hand is more satisfactory."

The Hurd Sifter and Blower.—This is really a sifting machine with an oscillating sieve for feeding the blast of a rotary blower, and is fully described as The Hurd Blower above.

"*The Goodheart Duster and Sprinkler.*—This machine, invented by Mr. James Goodheart, of Matawan, N. J. (patent No. 204720, June 11, 1878"), applies both powder and a liquid spray. "The dusting apparatus consists of a box with a screen bottom, the whole being agitated by means of a lever connected with one of the wheels. The sprinkler consists of a transverse pipe with a number of holes at its lower forward side. The machine is drawn over but one row of plants."—Bulletin No. 3.

ROTARY-SIEVE MACHINES.—In these the sieve containing the poison is round, generally cylindrical, and receives a rotary motion to assist the poison in gravitating through the small perforations.

"*The Robinson Dusting and Sprinkling Machine.*—Several machines

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have been patented that apply the powder by means of revolving perforated cylinders. The oldest of these seems to be one invented by Mr. William T. Robinson, of Huntsville, Tex. (patent No. 146205, January 6, 1874). It combines both sprinkling and dusting, in that pure water is sprinkled over the plants by an arrangement in front of a two-wheeled truck, while at the same time the powdered poison is dusted from revolving cylinders attached to the rear part of the truck. The powder thus sticks to the leaves and may be applied at all hours of the day. Both the duster and the sprinkler can be detached at will and used separately if necessary.

"From Plate LVII, Figs. 1 and 2, the former of which is a plan view, the latter a longitudinal sectional view of the machine, it will be seen that the dusting apparatus consists of an horizontal shaft, G, extending each way beyond the wheels, for reaching over the outside rows, and carrying three or more revolving screens or sieves, H, for sprinkling on powdered substances. Said shaft is mounted on the rear end of the frame, I, which is joined to the truck at, J, and suspended from the frame, M, by ropes, L, which are wound upon the shaft, N, or let out from it to shift the screens according to the height of the plants. The shaft is revolved by a belt, O, from one of the wheels of the truck working on cone pulleys, P O, for varying the speed of the screens or sieves, as may be required. The pulley, O, on the shaft, G, connects with it by a clutch, R, which is connected with a shifting-lever, S, for throwing the shaft out of gear when turning around at the end of the rows to save waste of material. T is a box for carrying the stock of powder from which to replenish the screens or sieves as they become exhausted from time to time. This box may be also used for a seat for the driver. The sieves are supplied through an opening in the ends, which may be closed by a gate or door of any kind, or by an opening in the side similarly closed.

"*The Davis Duster*, invented by Mr. Nicholas A. Davis, of Rusk, Tex. (patent No. 154651, September 1, 1874). This is almost an exact counterpart of the foregoing machine, but without the sprinkling attachment. The only peculiarity is the addition of springs to the revolving cylinders to prevent too great a discharge of the poison in case of a sudden jar.

"Plate LVII, Figs. 3 and 4, represents the invention attached to a cart. Fig. 4 is a cross-section through the line *y y*.

"A represents an ordinary farm-cart, across the rear end of which is secured the horizontal shaft, B, having its bearings in the arms, *c c*, projecting behind the cart. On the shaft, B, are placed two or more loosely-revolving perforated cylinders, E, being revolved upon the shaft, which carries a pulley, *a*, over which a band or cord works, passing to the hub of the cart-wheel, from which it receives motion, and thus causes the shaft, B, to revolve when the cart is in motion. Attached to the inner end of each of the outside cylinders is a spiral spring, *b*, coiled around the shaft, A, and so arranged as to secure an easy, gentle, lateral motion to the cylinders in case of a sudden jar given the machine. A similar spring may be used at the opposite end of the cylinders, so as to check the jar in both directions. This invention can be fixed to any kind of frame moving on wheels, and by a hand-crank and ordinary cog-gearing be successfully worked.

"*The Levy Duster*.—This duster, patented by Mr. Charles H. Levy, of Natchitoches, La. (No. 154690, September 1, 1874), also distributes the poison by means of revolving cylinders which can be adjusted to the height of the plant. The whole apparatus can be secured to the forward

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part of a saddle as well as to any cart. Plate LVII, Fig. 5, is a front view of this contrivance, and Fig. 6, a side view of the same, partly in section through one of the cylinders.

"AA are two cylinders, formed by attaching fine wire-gauze or finely-perforated sheet metal to circular ends or disks. To the inner surfaces of the cylinders A are attached longitudinal strips, B, to one side of each of which is attached a strip, C, of tin or other suitable sheet metal, which strips thus form flanges, which, as the cylinders revolve, raise the compound and allow it to fall back so as to keep it stirred up and prevent the heavier ingredients from settling and thus escaping in too large a proportion and unevenly. The cylinders, A, are placed upon the end parts of a shaft, D, and are secured in place adjustably by keys or nuts, so that they may be moved toward or from each other to correspond with the distance apart of the rows of plants. Upon the middle part of shaft, D, is formed a crank, *d'*, by means of which the cylinders are revolved, either by taking hold of the said crank, *d'*, directly, or by a short handle, E, pivoted to said crank. The shaft, D, revolves in eyes in the upper ends of two bars, F, the upper parts of which are curved to give room for the crank, *d'*, to operate. The lower parts of the bars, F, are parallel with each other, and pass down upon the opposite sides of the standard, G, to which they are secured by a bolt, H, which passes through a hole in the lower parts of the said bars, F, and through a slot in the said standard, G, so that by loosening the hand-nut, *h'*, of the bolt, H, the cylinders, A, may be raised and lowered, as the height of the cotton-plants may require.

"The bars, F, may be kept from turning upon the bolt, H, by lugs formed upon the inner sides of the bars, F, which enter the slot of the standard, G, or by a second bolt.

"The lower end of the standard G is branched, and has screw-holes formed through said branches to receive the screws or bolts by which the machine is secured to the forward part of a saddle, or to the frame of a sulky.

"*The Taylor Dusting and Sprinkling Machine.*—Another machine, invented by Mr. Thomas B. Taylor, of Mount Meigs, Ala. (patent No. 214205, April 8, 1879), is somewhat similar to the Robinson machine already described in that it has arrangements for both sprinkling liquids and for dusting powders, and both can be used simultaneously or each separately. The dusting apparatus does not differ materially from the perforated revolving cylinders already described, but the machine is interesting because it is to be attached to a common plow-stock, so as to do the cultivating and the poisoning at one and the same time. Plate LVIII, Fig. 6, is a vertical longitudinal section, and represents the plow-stock with both the sprinkling and dusting arrangements attached to the same.

"A represents the beam, B the handles, and C the standard of an ordinary plow-stock. To the forward and rear parts of the beam, A, are rigidly attached two standards, D, the rear one of which may be the upward extension of the plow-standard, C. The lower end of the forward standard, D, extends to or nearly to the ground, and has a plow-plate, E, attached to it to assist the plow-plate, F, attached to the plow-standard, C, in cultivating the ground, and to give steadiness to the machine, so that it may be readily controlled. To the upper parts of the standards, D, are pivoted the centers of the long front and rear bars of the rectangular frame, G, to the centers of the short side-bars, of which are pivoted the ends of the sheet-metal cylinder, H. This cylinder represents the sprinkler, and a more detailed description of it will be given under the proper head. It can be detached, and the dusting arrangement, which, in the figure, is represented as secured to the rear of the frame, G, can be put in its place. This dusting arrangement consists of a frame, O, similar to G, and to it

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are secured two semi-cylindrical plates, P, with their convex sides upward, and with their inner side edges near and upon the opposite side of the handles, B. In bearings in the opposite sides of the two plates, P, revolve the journals of two cylinders, Q, made of finely-perforated sheet metal or fine wire-gauze to sift the dry powder poison upon the plants.

"The sifting-cylinders, Q, are designed to be revolved by contact with the plants. The ends of the cylinders, Q, are provided with ring-flanges, R, to which are attached the ends of a number of rods, S, to strike against the plants and revolve the said cylinders. The rods, S, prevent the surfaces of the cylinders from being wet by moisture from the plants, which would cause the powder to stick to them and thus clog the discharge holes.

"The two sifting-cylinders, as well as the sprinkler, project of course on each side of the plow and distribute the poison on the two adjacent rows between which the plow is drawn.

"In practice it is found that the weight sinks the plow too deep, and to prevent this a large sliding-block is attached to the cultivator legs."—Bulletin No. 3.

RECIPROCATING-STIRRER SIFTERS.—In these the stirrer has a back-and-forth movement upon the stationary sieve face to work the powder through.

"*The Willie Duster.*—Mr. William T. Willie, of Brenham, Tex., has obtained a patent (No. 160986, March 16, 1875) for a contrivance which is but a modification of the method mentioned above of the application of the poison by a man on horseback by means of two sieves fastened to each end of a stick and carried across the saddle. The invention consists of two boxes suspended on a transverse bar, and made adjustable vertically and laterally according to the height of the plants and the width of the rows. The poison is dusted on two rows of plants by means of a system of vibrating sieves at the bottom of the boxes. The apparatus is intended to be secured to a riding-saddle in front of the rider.

"Plate LVIII, Fig. 4, represents a sectional view of the machine, the central figure showing a detailed section of one of the sifting-boxes.

"The letters A A designate two boxes of any suitable capacity, which are constructed with two fixed seives, *p p*, and movable sieves, *p'*, arranged between the fixed sieves and supported upon rods, so as to slide freely when the boxes are vibrated and aid in pulverizing the material, and at the same time scattering it uniformly. The upper sieves, *p*, will support the bulk of the material free from the scattering sieves, *p'*. Each box has secured to it a suspension-standard, B, having a number of holes, *a*, through it, arranged one above another, and adapted to receive suspension-pins, *b c*, and allow the boxes to be adjusted vertically for high or low plants. C designates a bar, from which rises a guide-rod, C'. This bar, C, is intended to be secured by the middle of its length to the saddle, and through its ends holes are made through which the standards, B B, are passed and sustained by means of the pins, *c c*. Supplemental holes are made through the bar, C, to allow the boxes. A A, to be adjusted for rows of plants varying in width. D designates a bar, the ends of which are slotted longitudinally to receive the standards, B B, and at or near the middle of the length of this bar, D, a hole is made to receive freely through it the rod, C'. The ends of bar, D, are notched at, *n*, and are attached to the standards, B B, by fitting these notches over the pins, *b b*, as shown in the figures."—Bull. 3.

ROTARY-STIRRER SIFTERS.—With these the stirrer is rotated upon the stationary sieve-face to work the powder through.

The J. W. Young Duster, patented (No. 188219) March 6, 1877, by Mr. James W. Young, formerly of Southfield, Mich., now of Saint

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Joseph, Mo., is a pair of sifters for two rows and carried suspended by a bar across the shoulders. Each sifter is a powder-box with semi-cylindrical perforated base, in which a brush is rotated to grind the powder through.

In Plate LVIII, Fig. 7, is seen the neck-yoke above, from which two adjustable bars hang, with forks suspending the cylinders which are perforated beneath. An adjustable slide can be set to cover more or less of the perforated area to regulate the amount to be sifted. Rotary brushes inside the cylinders are turned around, or with reciprocating motion, to work the poison through the fine holes. This is probably the best way to prevent clogging or cause a sieve to sift regularly, and this same principle seems to have been adopted in Mr. J. S. Smith's machine described in what follows.

Mr. J. W. Young, of Saint Joseph, Mo., has also devised a sieve-machine for powdering six rows at each drive, consisting essentially of a trough-shaped hopper about 27 feet long and having a concave perforated bottom, with a rotary stirrer operated therein. This is attached to a frame upon a pair of wheels which straddle a pair of rows. One of the draft wheels bears a band or chain wheel with a belt or chain driving a pully opposite the same and fast upon the axis of the stirrer, which is provided with a large number of radiating paddle-shaped teeth. When these are rotated by the belt, their ends pass through the poison in the hopper, and close to its perforated base, causing the powder to sift through upon the vegetation over which it is hauled. Not having seen the full-sized machine, but having examined a model and description of it, the impression produced is that the machine, if not made so long as to be too heavy, must be a good sifter for poisoning the upper surfaces of plants.

The following machine and the one preceding the last differ from the latter chiefly in the fact that bunches of brush-material are used instead of stiff stirrers, and it remains for the future to decide by experience which, if either, will prove best. The stiff stirrers promise to be the most durable, and my experience is that such usage of bristles causes them to become permanently flexed in one direction or too weak to give satisfaction. The plan of a stiff rotary stirrer is well calculated to cause the powder to sift out regularly.

The J. S. Smith Sieve machine, patented in 1881 (No. 247124), works the poison out through perforations, in one side of a cylinder, by means of a spiral brush rotated therein. This device appears in Plate LVIII. In fig. 5 is shown his small hand-machine for poisoning a single row. One side of the cylinder is seen to be perforated with the powder sifting out therefrom. The opposite half of the cylinder is covered by a horizontal hopper carried with one hand and a loop over the shoulder, while it can be tipped at will enough to make a portion of the powder feed into the cylinder to be worked out therefrom by the spiral brush turned inside the same by means of the gear wheels and crank.

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It seems a pity to pay for and carry on one hand all this gearing when it is superfluous, for only a slow rotation is necessary and a crank on the axis of the brush would answer, but the right to such a combination appears to be covered by one of Mr. J. W. Young's prior claims. The single passage from the hopper to the brush is large, and extends the whole length of the cylinder.

A larger machine drawn on wheels and arranged to supply two rows is also made by Mr. Smith. This is intended for poisoning insects on low crops, as potatoes, &c.; yet a similar apparatus could be mounted higher to be hauled above the rows of cotton. Gears on the main axle communicate its rotary motion to a rod bearing the brushes in the perforated cylinders. Over each cylinder is a powder-hopper, and forward therefrom a large box as a seat, and for conveying an additional quantity of poison. The main wheels straddle a pair of rows while a small trundle-wheel runs behind in the intermediate space, and a pair of shafts is provided for the horse which travels ahead in the same middle. The machine has adjustability to rows of different widths, and is strongly constructed.

The Eldridge Sifter.—The insect destroyer patented by Mr. Frank A. Eldridge, of Brenham, Tex., also designed to distribute dry poisons over the cotton plant, is thus described in the Department Report on Cotton Insects:

"The nature of the invention consists in the employment, upon a suitable vehicle, of two or more receptacles for containing poison powder which receptacles have perforated or sieve bottoms, and contain within them rotary stirring blades and brushes, actuated, as will be hereinafter explained, whereby the poison dust can be regularly and at the same time economically distributed upon two or more rows of plants at the same time.

"In Plate LVIII Fig. 1 is a top view of the machine; Fig. 2 is a side elevation showing one of the poison receptacles in section; Fig. 3 is a front elevation.

"A designates the axle of two transporting wheels, B B, from which axle rises a frame, C, carrying three poison-powder receptacles, D D D′, which are preferably of cylindrical form, and which have finely perforated bottoms, *a*. The two side receptacles, D D, are arranged so as to distribute the powder upon two rows of plants, and the rear receptacle distributes the powder upon the intermediate row, thus playing on three rows at the same time. Each receptacle contains radial blades, *b*, which are applied to a central shaft, *c*, and provided with brushes, *d*, which act upon the perforated bottom, *a*.

"The blades, *b*, stir the powder and prevent it from clogging, and the brushes compel it to pass through the screen-bottoms in a uniform manner.

"The upper ends of the shafts, *c*, of the receptacles, DD, have spur-wheels, *e*, on them, which engage with spur-wheels, *f*, on the ends of a horizontal shaft, E, which has its bearings on the top of the frame, C, and which is provided with pulleys, *g g g′*. The pulleys, *g g*, receive rotation from pulleys on the inner ends of the hubs of wheels, B B, through the medium of belts, *h h*.

"The rotation thus given to shaft, E, is transmitted to the shaft, *c*, of the blades and brushes which are in the receptacle, D′.

"The machine thus described will be propelled by two horses hitched to the draft-tongue, A′, and, if desired, the axle, A, may be centrally arched, so as not to interfere with the plants over which it passes."

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CHAPTER XIII.

MACHINERY AND DEVICES FOR THE DESTRUCTION OF THE WORM—Concluded.

VII.—INSECT MANIPULATORS AND MECHANICAL TREATMENT.

DISLODGING, CRUSHING, OR STIFLING THE WORMS AND CHRYSALIDS.

The practice of sweeping off or knocking or jarring off the worms, pupæ, or moths is related to that of taking them by *picking* (already considered in Chapter XI), and at the proper times may have some similar value. One difference is that in this method insects are generally manipulated by a tool or machine, though sometimes they are knocked off by the hand or foot. Various sweeping and beating devices are available, yet usually not commendable. Sticks, bats, bunches of branches, brooms or long brushes, &c., naturally suggest themselves. But these arrangements are applicable only with such force as to be not suitable, and the machines embodying them, in so far as they have been effective against the insects, prove also objectionably damaging to the bolls, &c.

The machines for manipulating plants, to remove insects from them, may be thrown into two categories: (1) *frictional drags*, as brushes, scrapers, &c., and (2) *beaters of the plants*, as clubs, flappers, &c. Though some of these have not been tried, it is doubtful if any of them will prove advisable for use upon the cotton crop. The best possibilities that I can suggest are, for (1) the use of a large long fringe of light ropes or other suitable materials, to be dragged along the row so that the ropes or equivalent elements fall into the plants, down among the branches and leaves, thoroughly to strike and wipe the surfaces of all the leaves and branches and create thus such friction and disturbance as to dislodge the worms. The elements in question should be numerous and hang in contact with each other, but not heavy or rough enough to break or scrape the plant or pull or knock off its bolls. Upon this plan I made a device of soft materials also intended to be kept wet with poison and thus wipe it off onto the leaves and branches. It consisted of a group of long cylindrical, slender, sausage-shaped stuffed bags, each being 1 or 2 inches in diameter. Bristles of animal or vegetable or fine metal fiber held in the twist of ropes thus used add much to their efficiency in removing anything from the foliage of the plants. The greatest possibility that I can propose for (2) is in the use of very

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broad flappers to strike the sides of the rows. Each of these should have a face of several square feet area, in order not to strike individual branches alone and break them off. An insect machine striking by a broad flapper operated by a ratchet and spring was constructed by me and tested on other plants about twenty years ago. This seems to me the safest way to apply the beating principle for removing anything from the plants. With each blow of the flapper there is generated a puff of wind for the same purpose.

In all these cases some *means of collecting or dispatching* the insects is provided. They are collected in a tray combined with the brusher or flapper and carried therewith beneath the row, or a hand-tray of wood, metal, or cloth is applied by one hand while the other is engaged in removing the insects to it from the plant. An elongated pan with a handle on one side is convenient. A shallow bag of cloth or netting having its mouth expanded on a frame provided with a handle also answers well. In such a net or deep cloth tray I recommend the use of a wad of cotton or a sponge filled with kerosene of the cheapest quality, or with benzine, which works quicker. In metal or wooden trays that are moderately deep the same can be used with advantage. Whatever is used should be wet with these well-known insecticides, benzine or kerosene. In shallow trays a layer of cotton batting or other suitable fibrous or porous matrix can be used to hold more of the hydrocarbons than will adhere on the vessel alone. Falling on this cushion the worms get a good dose, and it is then not necessary to wet the pan so often. Tar and other adhesives are less satisfactory.

Crushing the larvæ upon the ground by the foot, by a pounder, or by a heavy weight dragged along are other means of annihilating the dislodged insects, and under some conditions they may be left to be devoured by insectivorous animals or to die of the excessive cold, wetness, or dryness. These topics will have further notice below.

The Helm Sweeper and Crusher.—This was patented in (No. 139062) 1873, by Mr. J. Helm, of Hochheim, Tex. It is a portable frame, having brushes of split white oak or other material drawn, upon a heavy drag, straddle of a row of cotton plants to sweep off the worms or pupæ, and crush them beneath upon the ground. In Plate LIX, Fig. 1 is a side elevation, Fig. 2 is a transverse section through the line, *c c*, of Fig. 1, and Fig. 3 is a front view of the machine.

"The letter A represents a frame composed of two bottom boards, *a a*, of four or more uprights, *b b*, and a suitable series of cross-braces, *d d*. The boards *a a* are on a level and parallel to each other, and have wings, *e e* and *f f*, hinged to their inner and outer edges, respectively. To each of the front parts, *b*, is pivoted, at *g*, a lever, B, which carries a wheel, C, at its front end. There are thus two such wheels, C C, that rest on the ground in front of the apparatus. Draft-hooks, *h h*, are applied to the front ends of the levers, B, for hitching the draft animals to by which the machine is drawn over the field. The levers, B, can be swung on their pivots to raise the frame, A, on the wheels, C, whenever stones, stumps, or other obstructions are to be avoided. In such case the levers, B, are or can be locked to toothed plates, *i*, which are applied to the rear posts, *b*, as indicated in Fig. 1. When the machine is to be turned it is also

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necessary to elevate the frame, A, off the ground, and throw the whole weight of the apparatus upon the wheels, C. Whenever the frame, A, is thus raised the wings, *e* and *f*, will be swung up to clear the upper expanded parts of the cotton plants. This is done by connecting the two wings that are hinged to each board, *a*, with each other by a string, *j*, which passes over the lever, B, so that in swinging up such lever the string will be drawn with it to contract or swing up the wing. In the front ends of two horizontal bars, *l l*, that are longitudinally secured to the upper parts of the posts, *b*, is hung a transverse drum or shaft, D, from which a series of pointed brushes, E E, are suspended. Brushes, F F, are also rigidly affixed to a cross-bar, *m*, back of the shaft, D, and to inclined bars, *n n*, that are secured to the sides of the frame, A.

"For use, the machine is placed to straddle a row of cotton between the inner wings, *e e*. The boards, *a a*, rest in the furrows and the outer wings on the rising sides of the adjoining ridges, all as clearly shown in Fig. 2. The wings rest with their weight on the sides of the ridges. The machine being drawn ahead, the shaft, D, is revolved by its brushes, E, which come in contact with the cotton plants. Also, by subsequent contact with the brushes, F F, the worms are all swept to the ground, on which they are finally crushed and destroyed by the weight of the boards, *a*, and wings, *e f*.

"Apart from the circumstance that this machine straddles only one row of plants, it is extremely doubtful whether all or even a large portion of the worms would be crushed by the bottom pieces, considering the uneven nature of the ground."

The following machines carry a tray, of sheet metal, canvas, or other suitable material, supplied with tar, coal oil, or other stifling substances to catch and kill the insects by strangulation.

The Ewing Sweeper and Stifler consists essentially of two arms which beat off the worms from the row into a large flat tray drawn beneath charged with tar, &c. This is "one of the earliest used machines of this kind. It was inventedby Mr. William Ewing, of Columbia, La., in (No. 99995) 1869. Starting from the observation that the worms drop or throw themselves from the plant upon moderate disturbance of the leaves and branches, Mr. Ewing constructed a very simple machine, of which Fig. 4 is a top view and Fig. 5 a side view in Pl. LIX. In these drawings *a* represents a frame constructed of wood or other suitable material, *c d e* the wheels, and *f* a yoke or drawing device. Upon the front wheel, *e*, on either side, are pins, *g*, which act upon the lower ends, *h*, of the arms, *i*, as the wheel is rotated. These arms are pivoted to plates, *j*, and extend upward and outward so as to pass along the sides and over the top of the plants. To the upper part of these arms other tubular arms, *k*, are affixed, so that the brushes, *l*, secured thereto and held in place by eyes or ring, *m*, may be adjusted to the height of the plants. Between the frame a canvas, *b*, is stretched. This latter is smeared with tar or any other material to which the worms will stick or adhere for a reasonable length of time.

"This machine is intended to be drawn by hand, or by a horse or mule, between two rows of plants, the leaves and branches of which are agitated by the arms and brushes. The worms fall upon the smeared surface of the canvas, and may easily be gathered up and destroyed. It is evident, however, that only those worms are caught which fall toward

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the inside of the rows of plants between which the machine passes. To obviate this drawback, Mr. Ewing suggests the attaching to each side of the frame another light frame of wire rods or cane, reaching above the tops of the plants, thence down again to near the ground, and there carrying a canvas which is likewise smeared with tar.

"Two other machines, though originally intended for clearing potato-vines of their insect enemies, deserve notice here.

The Wood-Smith Tray Sweeper.—"The first of these was patented by Messrs. G. W. Wood and Charles H. Smith, of Faribault, Minn., in No. 214478 (1879), and consists of an apparatus mounted on wheels, which is drawn between the rows of plants, and by suitably shaped wings gathers the plants into a bunch and shakes them, thereby shaking off the larvæ into a receptacle from which they cannot escape. The parts of the apparatus are adjustable to suit the height of the plants.

"In Plate LIX Fig. 6 is a plan of the apparatus; Fig. 8 is a longitudinal section at the line, *x x*; Fig. 7 is a cross-section at the line, *y y*.

"Similar letters of reference indicate corresponding parts. *a a* are vertical standards, connected together by a cross-bar, *b*, at their upper ends. *c c* are wheels mounted on short axles fitted in the boxes, *d*, at the lower ends of standards, *a*.

"The standards *a* are at such a distance apart that the wheels, *c*, will run between the rows of plants and two rows of plants be between the wheels.

"The cross-bar, *b*, is made in two pieces, as shown, connected together by screws, so that the bar can be adjusted according to the width of the rows *e e* are wings, one at each side of the apparatus. The forward ends of the wings are attached to the standards, *a*, and their rear ends are connected together at the center line of the machine. These wings, *e*, are of suitable width, and they are attached with their edges vertical at the forward end, and are twisted so as to lie flat where they are connected together at the rear end. *f* is a pan-shaped receptacle, attached by arms, *g*, to a bar, *h*, that is suspended from bar, *b*, midway between the wheels, *c*. *i* is a vertical rod rising from the rear end of the receptacle, *f*, and passing through a hole in the ends of wings, *e*.

"The upper end of rod, *i*, is provided with a handle, *k*, by which the rear end of the machine may be managed. There are holes in rod, *i*, into which pins, *l l*, may be inserted to retain the rear ends of the wings, *e*, at the desired height, according to the growth of the plants. The strips, *m*, that form the sides of the receptacle, *f*, are pivoted by pins, *n*, at one end, so that the receptacle can be made wider or the reverse, according to the width of the rows.

"At the inner side of the wings, *e*, and projecting over the receptacle, are flappers, *o o*, hinged at *p*. Each of these flappers has a rod, *q*, passing through the wing that the flapper is hinged to, and connected with a crank-lever, *r*, hung at the outside of the wing. *s* is a lever fulcrumed at the forward end of the wing in such position that one end of the lever is acted upon by the teeth, *t*, attached to the inner side of the wheel, *c*. The other end of the lever is connected by a strap, *u*, that passes beneath a roller, *v*, to a rod, *w*, that is attached to crank-lever, *x*; *y* is a spring connected to lever, *s*, and to the wing, *e*. The teeth, *t*, depress the lever, *s*, and draw upon the crank-lever, *r*, and spring, *y*, and draw the flapper outward; but as soon as the lever, *s*, clears the tooth the flapper springs out quickly. The arrangement is the same on both flappers, *o*, and by that means a series of rapid blows are given upon plants gathered by the wings.

"A horse is to be attached to the whiffletree, *a'*, that is hung on bar, *h*. The horse will walk between the rows of plants that are to be operated upon by the apparatus,

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and the receptacle, *f*, will run on the ground between the rows. As the apparatus is drawn forward the plants pass beneath the bar, *h*, one row at each side of the bar, *h*, and pan, *f*, and the rows will be gathered together and bent down beneath the wings. The flappers will shake the plant and the larvæ will be rubbed and shaken off into the receptacle.

The Iske Sweeper and Stifler.—"This was patented by Mr. Anthony Iske, of Lancaster, Pa. (No. 173728), in 1876.

"It consists of an upright frame, open beneath, with two wheels in front, and is drawn over one row of plants at a time. A row of brushes, made of broom-corn or of any other suitable material, is fastened to a longitudinal beam, which is adjustable to the height of the plants and agitated by a contrivance similar to that in Mr. Ewing's machine. The worms dislodged by the action of these brushes fall in two canoe-shaped trays, which are supported by swinging arms, and slide along one on each side of the row of plants close to their base. On the outer side of each, these trays are provided with a smooth inclining shelf, which dips into the tray, and with a vertical backboard in order to prevent any worms from being beaten beyond these trays. In using this machine it is necessary to smear the trays with tar or coal-oil."

Other Catching-trays.—"Finally, having proved that the least touch of kerosene is as fatal to the cotton worm as it is to so many other insects, I have no hesitation in recommending as a cheap substitute for these brushing-machines, where youthful labor is abundant, the use of sheet-iron pans, over the bottom of which kerosene or coal-tar is spread. They proved very successful in 1877, when the Western farmers were contending with young locusts; and, drawn between the rows of cotton, while the worms are being brushed off in the manner recommended by Mr. Hoyt, they would prove equally satisfactory when the weather is not sufficiently hot and dry to insure the death of the worms otherwise. Or a still simpler arrangement might be adopted, viz: a cloth stretched on a frame that will draw between the rows and kept saturated with kerosene."

TRAPS FOR THE MOTHS.

While the foregoing devices aim at destroying the pest in its earlier stages, these are specially for capturing the parent forms—the moths.

The moths are attracted in three ways: 1. By lights which have on them an alluring effect; 2. By odors associated with the sweets of which they are fond, and 3. By both of these attractions combined. The causes of this attraction and other points connected with it have already been discussed in chapter XII, so we shall pass to the discussion of the various traps invented.

LIGHT TRAPS.—"The following enumeration of lamps for attracting and killing the moth is by no means a complete one. Some of the inventions are no longer used, and descriptions or samples of them unattainable; others are mere copies of such as are here described, and are

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therefore omitted; while still others are too complicated and expensive to warrant mention. A few words have still to be said concerning the mixture to be used, in connection with the lamps, for killing the moth. Almost any sticky substance, such as paint, tar, molasses, soap-suds, &c., will answer the purpose; but the cheapest and most effective means is to half fill the pan with water, and then pour in a tablespoonful of kerosene. The mixture can be strained off in the morning and used again.

"A simple lamp, first made by Col. Charles Lewis, of Hearne, Tex. has for some time been in use in the fields in the Brazos River bottom. It consists of the usual shallow tin plate placed upon a board that is nailed to the upper end of a stake or post. In the middle of this pan is placed a common kerosene lantern, large enough to burn the whole night, or at least the larger part thereof. In 1878 the planters near Hearne, Tex., were nightly burning over 1,000 of these lamps during a period of several weeks. The cost of this lamp, with the tin pan, is between 30 and 40 cents, and the cost of burning it one night about 1 cent. One lamp is generally used for every five acres where the land is level, but at shorter intervals where it is rolling.

"*The McQueen Lamp.*—This again does not materially differ from the others so far mentioned. Patented by Mr. B. F. McQueen, of Manack, Ala. (No. 166124, July 27, 1875), it consists of an ordinary lantern which is secured to the center of a shallow basin, beneath which is fastened a tube intended to fit on a post or stake. At the top of the lantern is a horizontal screen of tin, forming a reflector and serving also to precipitate the insects in the pan below. An illustration of this appears in Plate LX, Fig. 2, where C represents its attachment to a stake, B is the pan, A the lantern, and D the reflector. The reflector not only throws the light, but the insects that ascend at the side of the lantern strike it and fall down into the pan.

"*The Rigel Lamp.*—Invented and patented by Mr. Mark Rigel, of Alabama (patent dated January 28, 1873), this lamp differs only in being made so as to hang by a ring, and in the lantern having in addition to a horizontal reflector several vertical ones.

"There is another class of lamps of a still simpler nature, consisting of a torch-light, large enough to prevent its being extinguished by the wind, and placed in the middle of a tin pan. While cheaper than those with a steady light, they are decidedly less effective, and, moreover, they consume more oil. The simplest lamp of this class is a stout bottle filled with kerosene and mounted with a wick.

"*The Walker Lamp.*—This has been constructed by Mr. John E. Walker, of Winchester, Tex., and is represented herewith (Plate LX, Fig. 4). It consists of the usual tin pan placed on a post, and of a short, funnel-shaped pipe soldered to its center. A second hollow tube of the same shape, inverted, is attached to the bottom of the oil reservoir so as to fit firmly over the first. The reservoir has at the top a raised mouth,

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with a worm, through which the oil is poured and on to which the wick tube is screwed, as in the figure, the lower part of the tube which enters the reservoir being perforated. The shoulder above the screw is designed to prevent the falling of cinders or fire into the kerosene.

"One of the simplest lamps is that which I herewith illustrate (Plate LX, Fig. 5). It has been extensively used and is a mere modification and simplification of the Walker lamp. The reservoir is here soldered to the center of the pan, and the wick-tube to the top of the oil reservoir. The oil is poured in through an opening near the edge of the top of the reservoir."

Other lamp-pans not materially better than those described have been patented by Mr. J. R. Duke, of Norristown, Ark., Mr. J. R. Stephens, of Lone Star, Miss., Mr. C. R. Dudley, of Canton, Miss., Mr. R. Pitman, of West Point, Iowa, Mr. G. C. Cranston, of South Bend, Ind., and others, but with the examples described, a detailed account of all these will hardly be necessary.

Lamps in Motion will next be noticed.

The Le Blanc Cotton-moth Destroyer.—"As a result of the observation that the moths that are flying in the field are not so readily attracted by a stationary light as by one in motion, the two following machines have been invented with a view of being drawn or dragged through the field: The first of these is the Le Blanc cotton-moth destroyer, invented by Mr. Auguste Le Blanc, of Louisiana, La. (patent No. 101028, March 22, 1870), and represented at Plate LXI, Fig. 6. The apparatus is mounted on wheels, A, and consists of a platform, B, to which are secured a number of extensible posts, *c*, supporting a roof, D, from which is suspended by a chain or rope the devices to obtain the light. This device consists of the reservoir, E, which communicates through pipes, *a* and *b*, with a series of radial burners, F, which are arranged so as to form a circle of about 8 feet in circumference, though the dimensions may be increased or decreased. The posts, *c*, are rendered extensible by being formed in two parts, *c d*, the one fitting and sliding in the other. A series of holes, *e*, are made, one in the part, *c*, while a spring top or pin, *f*, is fixed to the other, *d*. By this means the burners may be raised or lowered at pleasure. The roof does not serve alone to shield the burners from rain, but, if painted with a white paint or with any other sticky substance, also helps to attract and destroy the moths. In order to use this machine effectually, Mr. Le Blanc suggests that the cotton should be planted so as to leave at intervals, say, of 2 acres, a space wide enough between the rows to permit the machine to pass through.

"*The Fordtran Cotton-Moth Destroyer.*—The second machine to be mentioned in this connection, invented by Mr. E. H. Fordtran, of Flatonia, Tex. (patent No. 196211, October 16, 1877)." It consists of a number of lamp-traps hung on a cross-bar, supported and connected with a horse by a pair of shafts, with their hind ends bent down to form runners to slide upon the ground. The cross-bar can be raised or lowered

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according to the height of the cotton, and is preferably set so low as to strike the tops of the plants. By clamp-screws the pan-lamps are attached to this bar. The runners are thought to do less injury than wheels would to the crop, and are placed so far apart as to straddle two rows or more. Different kinds of traps or torches, as inflammable balls, may be used on the frame if desired.

BAIT TRAPS.—These traps appeal to the sense of smell as associated with that of taste.

The Heard Bait Trap.—This device was patented by Mr. J. M. Heard in 1860, and is illustrated in Plate LXI, Fig. 4, which gives a section view. The circular pan, A, contains the bait, B, mixed with adhesive substance to attract and drown the moths. A partial cover, *a*, with a widely open center and forming a ledge, *a*, projecting horizontally inwards from the upper edge of the pan a short space above the liquid bait prevents the moths from getting at the bait without falling in, and then helps to stop their escaping. The inverted cone, C, and circular umbrella or rim, D, are for the moths to strike upon and to deflect or knock them down into the bait, which is made as follows: To a little anise, fennel, or other essential oil, add a little alcohol, and afterwards mix with this a gallon of molasses for each ounce of the oil used. A fresh mixture of the bait should be introduced once a week. According to the Agricultural Department Report on Cotton Insects, 1879, this trap has been "quite extensively used" in the South.

The Garrett Bait Trap.—Made by Mr. J. G. G. Garrett, of Port Gibson, Miss., is shown in plan section in Fig. 2, Pl. LXI. Upon the stake, *s*, is mounted a tray, *t*, containing the bait, *x*, and bearing a horizontal, inward-projecting edge, *e*, of sheet metal about three-fourths of an inch wide, and situated a short distance above the bait, *x*, to cause the moths approaching the bait to fall in and then prevent their escape. In the center is a support, *i*, for a light and having also a horizontal ledge. Mr. Garrett does not recommend the use of the light and has much better success with bait alone, so the former may be omitted. Above the whole is a roof, *r*, under the eaves of which, and at its ends, is space for the moths to enter. This will help prevent their escape and protect the bait from being affected by rains. The bait consists of about equal quantities of molasses and water, with a little vinegar or other attractive substances. Occasionally the insects may be strained out from the bait, which is then used again. Mr. Garrett's older lamp-trap, noticed below, is now abandoned for this one which has some preference.

TRAPS COMBINING LIGHT AND BAIT.—Traps may be made to combine the best features of both the preceding kinds and the two different attractives, bait and light, may be used simultaneously or in alternation. Where the bait is used at night associated with a light, the former may help some in drawing the insect to the latter, but when the light is once closely approached its dazing effect on the insect probably produces the entire effect which follows. The bait may be used independently in the daytime and the light with it or independently at night.

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The Net Trap.—A net trap of my own invention, and which I consider the best of this class, deserves the following consideration: Ob-Observing how moths attracted by light approach panes of illuminated glass, descending or ascending thereon, that most of the moths allured by light do not plunge into the blaze, but pass near it by a more or less circuitous course, often describing ellipsoid figures and returning to repeat the same, so that such moths are not caught by the common lamp-traps which have more or less cylindrical or cubic form, with the several horizontal diameters not extremely unequal, I planned a screen, made preferably of glass or glass and sheet metal in combination with a light, or bait, and other arrangements for taking moths and other insects, as represented in Plate LXI, Fig. 1. The two ends of the apparatus are alike. Observing one end with reference to the lettering; *s* is a stake having a slit sawed down into its top, on its side a cleat, *c*, and above this two opposite notches, *x*. In the slot is supported one end, *i*, of a large plate of glass, *i*, the larger the better. It had better be 3 feet square or more. A sheet of metal, *v r*, is bent to have two slight slopes like a roof, and is placed with its angle fitting upon the top edge of the glass. This angle may be bent up into a narrow fold, *v*, which will pinch firmly upon the glass. The roof may be very narrow, and good results are obtained when it is entirely omitted. Its outer margin should bend suddenly downward. The stake should straddle the glass to near the top thereof. The lateral halves of the stake thus form wings or flanges projecting at right angles from the glass. These may be made wider or with an edge projecting toward the light from the outer margins of each. Such a recurved flange is easily formed by tacking a strip of sheet metal upon the side of the stake. The projecting parts of the sides and the roof have a specific function, since the lantern is placed opposite a lower corner of the glass and the insects, attracted by it or by bait placed below, approach by a more or less circuitous course to strike against the glass. If the insect strike with but little force it flutters on the glass while sliding downward to fall into the other catching-devices below. But when the insect strikes the plate swiftly or at an angle it will be deflected off. The insect is observed habitually to move upward or horizontally as a rule on nearing the light and the plate, hence if it fly or glance suddenly off horizontally, the lateral wings catch it, or if it dart upward it strikes the roof, so that in either case it is precipitated downward into the devices beneath. The lower edge of the glass forms a septum through the long, wide, slot-shaped opening of the bottom of a trough-shaped hopper, *j j*, which has flaring sides so that moths descending from either side of the pane shall fall through it. The end of this hopper is supported upon the stake in notches, *x*, or otherwise. A large net, *n m*, of foundation lace or other fine netting has its mouth attached to the upper margins of the trough, which forms a narrowing entrance passage, projecting into the net. The top of the net is preferably held wide and upward, at *n n*, so that

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the light, *l*, shall illumine these regions, causing the insects which have entered to seek exit at these places where no outlet is to be found. Curved metal strips, *n j*, serve best to hold the net expanded in upward and lateral directions. From the insects caught the injurious ones should be selected and crushed in the folds of the net or otherwise killed, while the beneficial insects are set free through a large opening, *z*, in the base of the net. An easy way to keep this opening closed is to pucker it together and lay a brick or chunk, *z*, upon it, or tie it together.

This device, constructed and tested some years since, was intended to overcome such objections as have already been made to light traps, or in former pages, and also for the use of naturalists in collecting insects for their cabinets.

The indiscriminate killing of insects is certainly very unscientific and not to be recommended, yet where parties wish to adopt this abandoned practice to avoid the trouble of selecting the good from the bad, in which they often work against their own interests, a trough of destructive substance may be placed beneath the bottomless inlet, the end of the trough resting on the cleat, *c*. In case it is for drowning the insects, the trough should bear a projecting ledge a short space above the liquid, as in the bait traps to be noticed farther on. Such a trough supplied with attractive bait may be used as a bait trap apart from or in combination with the glass, which it still a valuable auxiliary to it.

But when bait is used it is preferable that the insects be not mixed in the bait and drowned thereby. It is better to use a shallow trough with flaring sides, or merely substitute for it a board on which the bait may be spread. Then the insects feed without drowning. In seeking the food they crawl down through the slot-shaped opening of the bottom of the trough-shaped hopper, toward the bait below it. Therefrom, instead of trying to escape through the hopper-slot, they fly off into the larger space surrounded by the net, and are thereafter to be selected and freed or killed.

I find the cotton moth is extravagantly fond of juicy canned peaches, and believe these are the best and most convenient bait for all seasons of the year, though any other sweet, succulent fruits may be employed in their season. Where divers species of insects are sought several kinds of bait may be inserted at once.

Stith's Cotton-Moth Exterminator (Plate LXI, Fig. 3).—"This exterminator is of the class which lures to self-destruction the mother moth on her first flight to deposit the worm-producing egg, and its essential peculiarities are (1) a day and night attractor-lantern, and (2) such embaying of the lantern side that the approaching moth falls a more certain prey into the usual trap-basin below.

"In the cut A and A are sides of the attractor-lantern; these sides are of opal glass, which by day is brilliant white and in twilight or by night, lighted by a lamp within, is most attractively luminous; each pane of the lantern is flanked by an out-reaching

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catch-wing, B, against which, or against a lantern face itself, one or the other, the moth, attracted by the lantern and lured as well by an odorous bait below, precipitated itself according to its habit of flying to or of passing close alongside of a brilliant object; a cover, C, projecting well over all, prevents upward escape even if elsewise possible to its now violently arrested flight, and all below lies a trap-basin, D, charged to a suitable depth with the common enticing bait, and effectual death-bath as well, of sweetened water and vinegar, poisoned with cobalt. Centrally up from the basin's bottom rises a conical socket to cap securely on to a stake so planted firmly afield as to hold the exterminator just sightable above the general surface of the crop foliage.

"The opal panes may be advantageously tinged with a trace of pink, to better simulate the color of the young cotton bloom; the catch-wings, the under side of the cover, and the inside of the basin are to be of cotton-leaf green, and all other visible parts a quiet earth color; the lanterns are to be of such size and so disposed that one may be readily sighted and sought from any direction within the field or approaching it. The exterminator is to remain baited and posted day and night, the lamp to be lighted as quietly as possible before twilight, and charged to surely burn the whole night through; its use to begin before the first moth of the season may be reasonably expected, and to continue till the last-belated straggler is surely gone. Operations, however thorough, confined to a limited area, unless absolutely secluded, can give only partial relief.

"To secure specimens of other 'fly-by-nights,' fit a wire-gauze floor a little below the rim of the basin, and place beneath it a sponge saturated with chloroform." (J. SMITH.) (Dept. of Agr. Report on Cotton Insects, 1879.)

"*The Pugh Lamp.*—Another somewhat more complicated contrivance of this class is that invented by Mr. Edward D. Pugh, of Fort Plain, Iowa (patent No. 130390, August 13, 1872). Plate LXI, Fig. 5, shows that it consists of the usual shallow pan, A, wherein is placed a rectangular case, B, made of glass and sheet-iron, with short feet attached to its bottom and with a cover, *c*. The bottom is perforated for ventilation, and a lamp, D, is placed within the case. So far there is nothing particular about this lamp, but it has, in addition, an arrangement to increase its attractiveness to the moths. Around the case is a frame, *a a*, with tubes, *b b*, attached to the inside and aperture communicating with the outside. E represents a common long-necked bottle placed on one of the tubes, *b*, on the inside of the case. The number of the frames, A, and of the tubes may vary, but on each of them a bottle is placed containing honey and wax or other suitable bait that is attractive to moths, which are consequently not only attracted by the light, but by the smell of the baits, and are either killed by falling in the pan or by passing through the apertures into the bottles, from which they cannot escape.

"*The Garrett Lamp.*—This was patented by Mr. James G. G. Garrett, of Port Gibson, Miss. (No. 133023), in November, 1872. The accompanying Plate [LX, Fig. 1] is a side view, partly in section, of the same. The letter A represents a stake driven into the ground, with a plank, B, nailed to the upper end. Upon this point is placed a sheet-iron pan, C, about 18 inches wide and 2 inches deep. In the center of the pan is a block or support, D, about 2 inches high, upon which is set an ordinary lantern, E, which is kept in place by being secured to the edges of the

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lank, B, by two or more cords, F. Into the pan, C, some coal-tar or molasses, or other suitable material, is poured so as to a little more than over the bottom thereof.

"*The Binkley Lamp.*—Mr. J. N. Binkley, of Columbus, Tex., uses a lamp which I herewith illustrate (Plate LX, Fig. 3). It is essentially the same as the foregoing, and consists, like Garrett's lamp, of a tin plate which may be rectangular or round, and which is placed on a board nailed to the upper end of a stake or pole. A lantern of the form shown in the figure is soldered to the center of the plate, the cover of which lantern has openings to aid ventilation, and may, when necessary, be removed. A common kerosene lamp, with or without chimney, is placed in the lantern, and the pan is half filled with water and a little kerosene on top, or with soap-suds or molasses, &c."

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CHAPTER XIV.

HISTORY OF THE LITERATURE AND BIBLIOGRAPHY.

HISTORY OF THE LITERATURE.

Concerning the ravages of the chenille in the West Indies during the last century, we find mention in several books of travel. Daniel McKinnen (1802) gives an account of the appointment of a commission by the general assembly of the Bahamas in 1801 to investigate the causes of failure of the cotton crop. Bryan Edwards (1805) mentions the great damage done in the islands by the chenille in 1788 and 1794. Dr. Chisholm (1830)* treats at length of the chenille as observed by him in British Guiana in 1801–'02. George R. Porter (1833), in speaking of cotton culture in Guiana, copies much of this last-named article, as also does Dr. Andrew Ure (1836).

With regard to the early appearances in the United States, we have been able to find no contemporaneous accounts of any value. Nothing worthy of mention seems to have been written until after the great caterpillar year of 1825. Perhaps previous to this year, perhaps later, a memoir upon cotton was written by Thomas Spalding, of Georgia, a well-known agricultural and historical writer, in which the chenille must have been treated at some length. We have been unable to find that the memoir was ever published. It was transmitted in manuscript to Ure and was extensively quoted by that author. It was also freely used by Hon. W. E. Seabrook (1844), of whose treatise we shall speak later.

In January, 1827, Dr. C. W. Capers, of Georgia, sent specimens of the parent moth to Thomas Say, father of descriptive entomology in North America. They reached the latter in November of the same year, and in May, 1828, his answer to Dr. Capers' letter, describing the moth as *Noctua xylina*, was published in the *Southern Agriculturist* (see Capers, 1828), accompanied by brief popular descriptions of the egg, larva, and pupa, and also by an account of the ravages of the worm from 1800 to 1827, by Dr. Capers himself. The description, with the accompanying correspondence, was published by Say in the New Harmony *Disseminator* in 1830, and was afterwards reprinted by Fitch (1857), and may be found in Say's collected writings (Leconte's edition, I, 369). This article of Dr. Capers' was the first scientific effort upon the Cotton Worm,

* The full titles of these works and all others designated simply by authors and date can be found by reference to the bibliographical list.

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and excited a temporary interest in the subject. It was followed by several unimportant articles in the *Southern Agriculturist* and other southern periodicals during 1829; but the interest apparently soon died out, and there was a dearth of items for a number of years—a fact which is partially explicable on the ground that the worms were at no time remarkably numerous between 1825 and 1846. The one noticeable article during this period is that of Hon. Whitemarsh E. Seabrook (1844), who devotes three pages of his memoir upon cotton to the consideration of the caterpillar, its history, and the means employed against it. This account, though short, is accurate and valuable and has been much quoted.

As one would naturally expect, the year 1846 brought forth a great number of articles good and bad. The first among these to be mentioned is the letter written by Thomas Affleck to the *American Agriculturist* in August, 1846, from which we have already quoted in Chapter III, describing the devastation in Mississippi and giving an account of the past history together with some facts in the natural history of the insect. The most interesting point about this letter is, however, the fact that it contains in the following words the first hint of the migration theory, which has since occupied so much attention among writers on the Cotton Worm: "But whether we at all times receive our supply from this source" [hibernation] "or whether (which I think is quite as probable) they are not unfrequently brought on a gale of wind from the West Indies, Mexico, or the coast of Guiana, will be difficult to decide."

From 1846 to 1852 followed quite a stream of articles in the *Southern Cultivator*, *De Bow's Review*, *American Cotton Planter*, and other prominent periodicals; but very few were of any permanent value. During the fall and winter of 1846–'47, Dr. D. B. Gorham, of Bayou Sara, La., made observations which led to an article in *De Bow's Review* (Gorham, 1847), in which the migration theory is quite extensively elaborated. The idea was an original one with Dr. Gorham, and he arrived at it from the observation that all the late fall pupæ that he collected were parasitised. Hence, arguing a total destruction of the last brood, he was forced to some other conclusion than hibernation to account for the starting of the stock the ensuing year. His views were plausibly expressed, although based upon so erroneous a standpoint, and his article excited much interest among the reading planters. The article will be of permanent interest, however, only as containing the first mention of any parasite upon the Cotton Worm. The author gives quite a full description—although he gives the species no name—of *Pimpla conquisitor*. It is interesting to notice that of all the articles which this announcement of the new theory called forth not one of the writers accepted Dr. Gorham's views. Among the more prominent of these papers may be mentioned the editorial by William Jones in the *Southern Cultivator* (Jones, 1847), and the article by P. Winfree in *De Bow's Review* of the same year. The latter writer was the first to mention the good offices of ants in killing the caterpillars.

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In the fall of 1846 Mr. Affleck, knowing of Say's name and description of the moth, wrote to Dr. T. W. Harris, the New England entomologist, sending specimens of the moth, together with the request that he would redescribe it and place it in its proper "modern" genus Harris was at a loss, as he had nothing in his collection similar to it, and so he forwarded the specimens to Edward Doubleday, a celebrated English lepidopterist. Doubleday showed the specimens to the London Entomological Society, and answered Harris that the species would fit in no modern genus, but that it came nearest to *Ophiusa*. This opinion Harris transmitted to Affleck as his own. The whole correspondence forms rather an interesting chapter in the history of the Cotton Worm. Affleck's original letter to Harris has not, so far as we can find, been published; but the gist of the latter's final reply can be found in an excellent article in Affleck's *Southern Rural Almanac* for 1851, in which the moth is designated as *Ophiusa* (*Noctua*) *xylina*. Harris's letter to Doubleday and the latter's reply will be found in Harris' Entomological Correspondence, Boston, 1869, and Doubleday's remarks upon the specimens before the London Entomological Society are to be found in the Proceedings of that society for 1848.

Mr. Affleck's article, though short, is an excellent one. In his 1846 article he had advocated the hibernation of the pupæ, but this he now rejected, and, from actual observation, published the fact that the moth hibernates. He also, in the 1851 article, gives the first figure ever published of a parasite of the Cotton Worm—probably *Pimpla conquisitor*.

In 1854 two papers of a certain degree of interest were published. B. C. L. Wailes, in his 1854 report on the Agriculture and Geology of Mississippi, article Cotton, devoted a short space to the consideration of the caterpillar, and accompanied it by a colored plate illustrating the different stages. The principal interest of the paper arises from the curious mistake which Mr. Wailes made in the scientific name of the moth. He calls it *Depressaria gossypioides*. This name he must have gotten from seeing somewhere an account of the East Indian Cotton Boll-worm, the *Depressaria gossypiella* of Saunders. Still the habits of this insect are so different from those of our Cotton Worm that is very difficult to see how he could suppose them identical. As for the remainder of the article there is nothing in it that is not twenty years behind its time.

The other 1854 article which we would mention was published by Dr. W. I. Burnett in the Proceedings of the Boston Society of Natural History. Here again, for the third time, was put forth the migration theory. Whether it was his own idea or whether he picked it up among the planters of South Carolina and Georgia, whither he went for a number of winters for his health, is difficult to say, but the latter is more probable. The whole paper seems to have been written mainly from hearsay, and contains a number of mistakes which Dr. Burnett would hardly have made from his own observations.

In the autumn of 1853 or 1854 Mr. Townend Glover went South to

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study cotton insects under the auspices of the Agricultural Bureau. His report on the caterpillar, which he treats under the name of *Noctua xylina*, and which was published in the Agricultural Report of the Patent Office for 1855, was the most accurate yet published, and formed the basis of most of the articles on this subject for the next fifteen years. It was, in fact, the first article written by a professed entomologist. The paper is accompanied by good figures of all states of the insect. It gives popular descriptions of the egg, larva, pupa and adult, and quotes from correspondents of the Bureau many interesting facts respecting the appearances from year to year. Parts of Dr. Capers' article are also quoted. The remedies given are lights, fires, and poisoned sweets.

Nothing original appeared now for a number of years. Glover's article was copied many times. J. A. Turner, however, in his Cotton Planter's Manual, New York, 1857, by way of variety, quotes Dr. Gorham quite fully. In 1864 Mr. A. R. Grote announced, in a paper entitled "Notes on certain species of North American Lepidoptera," in the Proceedings of the Entomological Society of Philadelphia, Vol. III, the identity of Say's *Noctua xylina* and Guenée's *Anomis bipunctina*. *Xylina* being the first published, the specific name *bipunctina* was dropped, while the new generic name *Anomis* was retained, forming the combination *Anomis xylina* by which the species was known for some ten years.

With the close of the war and the beginning of the subsequent disastrous chain of caterpillar years, communications upon the Cotton Worm in the Agricultural Reports and in the various agricultural periodicals became much more numerous than they had been before. Both the annual and the monthly reports of the Department contained much by Glover that was of value. So, too, the letters of G. W. Morse and J. M. Ferguson were interesting and well worthy of attention. Both these letters, published in the Monthly Reports for 1867, advised the hand picking of the early brood, on the ground that it appeared in limited localities, and in small numbers. In the same volume O. H. Hempstead detailed very successful experiments in killing the moths with a home-made trap-lantern.

In 1868 Walsh and Riley commenced the publication of the *American Entomologist*, the first volume of which contained several interesting articles on the Cotton Worm.

The *Southern Cultivator* for 1869, '70 and '71 contained several papers of value upon this subject, most of them from the pen of the editor, Mr. William Jones; and the *Rural Carolinian*, commencing publication in 1869, contained, in the next few years, many good articles, none of them, however, of striking originality. First among these we may mention a lecture delivered before the Farmers' Club of Woodville, Miss., by Dr. D. L. Phares, in May, 1869, and published in the *Carolinian* for August, 1870. The article is accompanied by a full-page lithograph, not very true to nature, of the worms at work, and contains a good résumé

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of the history. In 1871 the same periodical published from month to month rather a sharp controversy on the subject of certain points in the natural history of the worm, between Dr. E. H. Anderson, Mr. C. R. Dodge, and Mr. A. R. Grote.

The *Carolina Farmer* for 1869 contained an interesting item in the shape of an account of a mass meeting of planters at Opelousas, La., to discuss the Cotton Worm, at which meeting it was decided to unite in the making of fires to destroy the moths.

In 1870 was published our second report as State Entomologist of Missouri, which contained a short article on the Cotton Worm, correcting some previous mistakes, and giving facts gathered from an extensive correspondence with Thomas Affleck and other prominent planters.

In August, 1872, there appeared an editorial in the *Mobile Register* (August 18, 1872), on the Cotton Caterpillar, which contained, as far as we can find, the first published mention of the fact that Paris green was being used as a remedy.[57] This article was much copied by the agricultural press, and may be found in the *Carolina Farmer* for September, 1872, and in the *Southern Farm and Home* for October of the same year.

In June, 1873, the *Illustrated Journal of Agriculture* (St. Louis) contained an abstract of certain remarks on the subject of Paris green made by us before the National Agricultural Congress, meeting at Indianapolis. This article was at once copied by nearly all the prominent periodicals South, and furnished the text for many articles by other writers. Among these we may mention the "Essay on the best Mode of using Paris Green for the Destruction of the Cotton Worm" by an "Alabama Planter" (C. F. Prout, of Demopolis, Ala.).

In the fall of this year the Department of Agriculture sent out circulars asking the opinions of planters on the Paris green question, and in the Annual Report for 1873 the answers were compiled, giving a very general verdict in favor of the poison.

The interest in the subject fast increased after this year, and the number of newspaper articles increased in proportion. In 1874, a prize offered by certain citizens of Selma, Ala., for the best essay on "Practical Modes of destroying the Cotton Worm," was awarded to J. D. Hoyt, of that city, and the essay was printed in pamphlet form. In the essay are discussed Paris green, arsenious acid, fires, lantern-traps, and the plan of knocking the worms from the plants.

In March, 1874, our Sixth Report on the Insects of Missouri appeared, containing a 7-page article on the Cotton Worm, devoted principally to the consideration of Paris green as a remedy. There is also a discussion as to the hibernation of the insect, and as to its northern range. In this article we reiterated our belief in the hibernation of the moths and suggested the probability of a northern food-plant other than cotton.

In the Monthly Report of the Department for February and March, 1874, p. 125, the views of the entomologist (Mr. Glover) are stated on the question of hibernation. His theory was "that in the more north-

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ern portion of the cotton-belt the frosts of winter destroy the insect in all its stages, unless in situations of unusual protection, but that in the more southern portion, where severe frosts rarely occur, they survive the risks of winter." This theory of Glover's (given by the editor of the Report, Mr. J. R. Dodge) was untenable so far as it included the earlier states of the insect, but so far as it refers to the moth it anticipated the true state of things, as we have proved in this investigation.

Early in 1874, Mr. Grote, in his "List of the Noctuidæ of North America," announced his belief that the Cotton Worm Moth hitherto called *Anomis xylina*, is identical with the previously described *Aletia argillacea* of Hübner. This view was accepted on his authority by most subsequent writers, and in the first edition of this work we treated of the species by the latter name.

At the Hartford meeting of the American Association for the Advancement of Science, the same year, Mr. Grote read quite a lengthy paper entitled "The Cotton Worm of the Southern States (*Aletia argillacea* Hübner.)" In this is put forth (as original), for the fourth time in little more than a quarter of a century, the familiar migration theory. Yet it is approached in a more careful manner, and the arguments advanced in its support are ingenious, and would have had much force had they not flowed from mistaken premises. The paper shows lack of any practical knowledge of the facts. In the discussion which followed its reading we disputed its conclusions on hibernation, and the author has added a paragraph to the paper, as printed in the Proceedings of the Association, which was not in it as originally read and published in the New York Tribune extra, and which embodies the very point of our criticism. Mr. Grote, starting with the proposition that there are no parasites upon the Cotton Worm, argued that the absence of such parasitic checks can be easily accounted for by supposing that the States are not the natural habitat of the species, but that there is an influx of the moths every year. Dr. Gorham, on the other hand, bred many parasites, and yet from this opposing fact drew the same conclusion, supposing the last brood of worms to be entirely killed by the parasites, thus necessitating an incoming of the moths the ensuing season from some more southern country.

From this date (1874) up to the commencement of the official investigation nothing of special importance appeared. There were many newspaper articles, it is true, but they were based on the writings of others.

Early in 1878 appeared a few copies (printed from stone for private distribution) of a quarto volume of plates and explanations, by Mr. Glover, and entitled "Manuscript Notes from my Journal—Cotton and the Principal Insects, &c., frequenting or injuring the Plant in the United States." This is by far the most creditable work on the subject that had appeared up to that time, and the plates were specially commended in the award of a gold medal made to Mr. Glover for his exhibit at the Paris Exposition of 1865.

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The newspaper announcements of the investigation we began in 1878 were very numerous, but no article worthy of note appeared before September, when, in the *Atlanta Constitution*, we suggested a probability, which we soon afterwards proved to be a fact, that the moths feed upon the nectar secreted by the foliar glands of the cotton plant.

During 1878 and 1879 the literature is confined principally to the goings and comings and work of the agents of the Department of Agriculture and of the Entomological Commission. In May, 1879, however, we read a paper on "The Migrations and Hibernation of *Aletia argillacea*" before the National Academy of Sciences, in which we gave the proof which had been collected in favor of the hibernation of the moths. Abstracts of this paper were published in *Science News* for June 1, in the *Scientific American* of June 14, and elsewhere.

In August of the same year, we also read a paper before the American Association for the Advancement of Science, entitled "The Cotton Worm in the United States," and devoted principally to disproving the migration theory as put forth by Grote, and also announcing some of the recent discoveries resulting from the investigation. In addition to these two papers, we had, in July, delivered a lecture on the Cotton Worm before the Mobile Cotton Exchange, which was published in the *Mobile Register* for July 9, and afterwards extensively copied throughout the South. In this paper will be found the first published suggestion of the great influence which parasites and other insect enemies of Aletia exercise on the appearance of the worms upon low grounds, and the part they play in the well-known abundance of the worms during wet as compared with dry weather.

In January, 1880, was recommenced the publication of the *American Entomologist*, after a lapse of nine years, and the volume for that year (Vol. III) contains much information upon Aletia and other cotton insects, derived from our own observations and those of our assistants.

January 28 appeared, from the Interior Department, Bulletin 3, United States Entomological Commission, by C. V. Riley, entitled "The Cotton Worm: Summary of its Natural History, with an Account of its Enemies, and the best Means of controlling it; being a Report of Progress of the Work of the Commission." This is a pamphlet of one hundred and forty-four pages, with one colored plate and some eighty-four woodcuts. It was the most complete treatise which had been published up to that date, and it contained much new matter. Over sixty pages are devoted to a consideration of remedies.

In May, 1880, a few unbound and incomplete copies of a more elaborate volume on the same subject, by the Department of Agriculture, were sent to some members of Congress. It is called "Report upon Cotton Insects," and the first two hundred and eighty-four pages are devoted to an account of Aletia. The work was not completed or distributed until the following August. This volume is published under the name of J. H. Comstock, though it really consists of the first year's

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work in the investigation conducted by us, as then Entomologist of the Department, together with the results of Mr. Trelease's observations during the summer of 1879. An interesting and unique feature of the volume is Mr. Trelease's chapter on Nectar and its Uses, which is treated with special reference to the significance of the extra-floral nectar glands of the cotton plant.

In September, 1880, the *New Orleans Democrat* published a long letter on the Cotton Worm from us, giving some of the later results of the investigation, under the following sub-heads: *Principles established; The Best Poisons; London Purple; Pyrethrum; Oils; Improved Appliances; Poisoning from Below; Early Poisoning; Weather—Conclusion.*

We refer to the bibliography for a number of later newspaper articles, and will only call attention, in conclusion, to the article by J. P. Stelle, in the *Mobile Register*, July, 1881, entitled "Killing Cotton Worms," in which the writer discusses *Our Native Plants, Pyrethrum, London Purple, Paris Green, Arsenic;* and to the lecture delivered by us before the Convention of Cotton Planters at the Atlanta Exposition, November 4, 1881. It was published in full in the *Atlanta Constitution* for November 5, and also in a pamphlet issued by the Department of Agriculture, entitled "Address of Hon. Geo. B. Loring, Commissioner of Agriculture, and other Proceedings of the Cotton Convention held in Atlanta, Ga., November 2, 1881." The lecture was devoted to a review of the natural history of Aletia, but principally to a discussion of improved appliances for its destruction. It was also republished in the Annual Report of the Department of Agriculture for 1881–'82, pp. 152–157.

During the years 1879, 1880, and 1881, the *Galveston News*, the *Selma Times*, the *Mobile Register*, and the *Atlanta Constitution* have all contained many interesting items and communications upon cotton insects, as will appear from the following bibliography, which, while not including all the titles of fugitive articles, will be found to contain all the more important references, as we have carefully preserved all such writings on the subject during the past decade.

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[Plan of work of the Commission for 1880.]

Bailey, J. F.—American Entomologist, iii, p. 77, 1880.

[A mere note accompanying specimens of the Cotton Moth captured February 12, on Mock Orange.]

Bailey, J. F.—"Pyrethrum on Cabbage and Cotton Worms." American Entomologist, iii, p. 296, 1880.

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Bailey, J. F.—"Yeast ferment for Cotton Worms." American Entomologist, iii, p. 296, 1880.

Bailey, J. F.—"Destruction of fruit by Aletia." American Entomologist, iii, p. 297, 1880.

Barbee, W. J.—"The Cotton Question." New York, 1866.
[On pp. 151–238 quotes, entire, Glover's articles in Department of Agriculture Reports for 1854–'55.]

Beach, A. E.—"Remedy for the Cotton Worm." Science Record, pp. 370, 371, 1874.
[Paris green.]

Bethune, Rev. C. J. S.—Discussion with Riley, Mann and Lintner on Northern occurrences of Aletia.
[See Report of the Proceedings of the Entomological Club, American Association for the Advancement of Science, 1880, in Canadian Entomologist, xii, p. 176, September, 1880.]

Boyle, J. F.—"On the Culture and Commerce of Cotton in India and elsewhere. London, 1851.
[Gives on p. 232 an account of the chenille—*N. xylina*—made up from Chisholm, Ure, and Seabrook.]

Brandt, Louis.—"A Suggestion." Cuero (Tex.) Bulletin, January 3, 1882.
[Has experimented with salt and found it of no avail; but advises the introduction of the English Sparrow.]

Breed, Daniel.—"Description and figures of recent inventions for insect destruction." Field and Forest, iii, p. 92, 93, fig. 23–27, December, 1877—Psyche, Record No. 946 *n*.
[For destroying *Aletia*, *Leucania* and *Doryphora*.]

Burnett, W. I.—"The Cotton Worm of the Southern States." Proceedings of the Boston Society of Natural History, iv, pp. 316–319, 1854.
[An account of the insect, short and mostly from hearsay. Proposes the migration theory.]

Capers, C. W.—"On the Cotton Caterpillar." Southern Agriculturist, i, p. 203, May, 1828.
[Quotes Say's original description as sent to him in MS.; gives a full account of ravages from 1804 to 1827 and describes in a general way the egg, larva, pupa, and adult.]

Carolina Farmer.—"Death to the Cotton Worm." 1869, p. 142.
[Report of a meeting of planters at Opelousas, La., at which it was decided to unite in making fires to destroy the moths.]

Carolina Farmer.—"The Cotton Caterpillar (*Anomis xylina*)." Vol. iv, p. 278, 1872.

Carolina Farmer.—"The Cotton Caterpillar." Vol. i, p. 142, 1868.

Chisholm, Dr.—"Cotton." Sir David Brewster's Edinburgh Cyclopedia. Edinburgh, 1830.
[Draws up a description of the chenille in Latin. Gives an extended account of its habits as observed by him in Demerara (British Guiana) in 1801–'2, and proposes, as a remedy, fumigation with sulphur.]

Colorado Citizen.—"Of the Cotton Worm." July 17, 1879.
[Result of an interview with Professor Riley, giving progress of work of the Commission.]

Colorado Citizen.—"Investigator and the Cotton Worm." September 11, 1879.
[An editorial defense of Professor Riley against "Investigator."]

Columbus (Ga.) Inquirer.—"The Cotton Caterpillar." February 11, 1874.
[Advocates at length the spontaneous generation of the caterpillar.]

Comstock, J. H.—Report upon Cotton Insects. Washington, 1879 (Department of Agriculture). May 18, 1880.
[Devotes the first 284 pages to the consideration of Aletia, with a colored plate and many illustrations. Results of the first year's investigation under Riley, together with reports from Mr. William Trelease.]

Comstock, J. H.—The previous work condensed in Annual Report of the Commissioner of Agriculture, 1879, pp. 263–332.

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Connerly, D. C. B.—"The fight with the Vermins." Eutaw Whig and Observer, August 7, 1873.

[On the use of Paris green for Aletia.]

"Cotton."—"The Cotton Caterpillar, No. 5. The Moth Fly, or Imago." Navasota (Tex.) Tablet, June 11, 1880.

[Seems to be a compilation from Bulletin 3, United States Entomological Commission.]

"Cotton."—"The Cotton Caterpillar, No. 7. How to destroy them." Navasota (Tex.) Tablet, June 25, 1880.

D., J. R.—"The Cotton Caterpillar." American Cotton Planter, August, 1850.

[Advises poisoned sweets and striking down the moths with paddles.]

Reimpr.—Cotton Planter's Manual, by J. A. Turner. New York. p. 160, 1875.

Dana, W. B—Cotton from Seed to Loom. New York. 1878.

[On p. 117 gives a short account of the caterpillar.]

De Bow's Industrial Resources of the Southern and Western States.—"The Cotton Caterpillar." p. 170, 1852.

[Quotes extensively from Affleck.]

De Bow's Industrial Resources of the Southern and Western States.—"Cotton Worms." p. 171, 1852.

[Advocates use of Plaster of Paris.]

De Bow's Review.—"The Cotton Worm, its Character, Habits," &c. Vol. xvii, pp. 451–459, 1854.

Department of Agriculture.—"Birds and the Cotton Worm." Monthly Report of Department of Agriculture. p. 273, 1870.

[Advocates the sowing of millet in the fields to attract birds, and also the introduction of the English Sparrow.]

Department of Agriculture.—"Cotton Insects." Special Report No. 8, p. 8, September, 1878.

[An account of the progress of the investigation up to September.]

Dickerman, C. W.—How to make a farm pay. Philadelphia, Cincinnati, Chicago, and St. Louis. 1869(?).

[On pages 222–223 speaks of the Cotton Moth; quotes mostly from Lyman.]

Dodge, C. R.—"A Word about Cotton Caterpillars." Rural Carolinian, iii, pp. 87–88, 1871.

Dodge, C. R.—"Cotton Caterpillars; One Word More." Rural Carolinian, iii, pp. 263, 264, 1871.

[Corrects statements in the last-mentioned paper.]

Dodge, C. R.—"The Paris Green Remedy for the Cotton Caterpillar." Rural Carolinian, v, pp. 193–195, 1874.

[Summarizes the replies to the Department of Agriculture circular of 1873.]

Dodge, C. R.—"Injury to Cotton by Insects." Rural Carolinian, v, pp. 417, 418, 1874.

[Tabulates the first appearances of the worm, and states Professor Glover's theory of the partial hibernation of the insect in all states, which the table upholds.]

Dodge, Lewis A.—"The Cotton Caterpillar." American Naturalist, vii, p. 213, April, 1873.

[Gives popular southern ideas and wrongly figures *Heliothis phlogophaga* Gr. for the Boll Worm.]

Doubleday, Edward.—Transactions of the London Entomological Society, 1848. Proceedings, p. 33.

[Mentions having received the American Cotton Moth from T. W. Harris, and states that it belongs to no European genus, coming nearest to *Ophiusa*.]

Doubleday, Edward.—Entomological Correspondence of T. W. Harris. Boston, 1869. p. 173.

[In a letter to Harris, dated April 2, 1847, states that the Cotton Moth is near to *Ophiusa* but is a new genus.]

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Du Bose, J. W.—"Influence of Winds on Aletia." American Entomologist, iii, p. 105, 1880.

Edwards, Bryan.—History, Civil and Commercial, of the British Colonies in the West Indies. Philadelphia, 1805–'6.

[Containing an account of the ravage of the *chenille* in the West Indies in 1788 and 1794.]

Evening Star (Washington, D. C.).—"Cotton Worm and Cotton Culture in Foreign Countries." April 13, 1880.

[Brazil and Mexico.]

Farmers' Home Journal.—"Cotton Moths." May 14, 1881.

[An account of successful experiments by J. D. Austin, of Fannin County, Texas, with trap-lanterns. Also published in the *Galveston News* of July 21.]

Farmers' Review.—"The Cotton Worm." August 26, 1880.

[Copies the supplementary circulars sent by Professor Riley to agents of the Commission.]

Ferguson, James M.—"The Cotton Worm." Monthly Reports of the Department of Agriculture, 1867, pp. 288–289.

[Gives observations on the natural history of the Cotton Worm and advises hand-picking of the first brood.]

Fletcher, James.—"The Cotton Worm." Canadian Entomologist, xiii, p. 233, November, 1881.

[Report of the Annual Meeting of the Entomological Society of Ontario. Letter from Mr. Fletcher, asking for observations on Aletia; and notes of their capture, by Messrs. Moffat and Reed.]

Florida Dispatch.—"The Cotton Plant." July 16, 1879.

[A lengthy article, one of the sub-heads being "The Cotton Caterpillar." A short review of the natural history, advising Paris green as a remedy.]

Forsley, C. G.—"Cotton Worms—Noctua gossypii." New Orleans Commercial Times, September 22, 1846.

Fugate, R. N.—"The Cotton Worm, or Caterpillar." Southern Farmers' Monthly, August, 1880.

[Hibernation of Moth and Influence of Weather.]

Fuller, A. S.—"Paris Green and the Cotton Worm." New York Weekly Sun, November 4, 1874.

Galtney, J. R.—"The Cotton Army Worm." Southern Herald, Liberty, Mississipi, May and June, 1869.

[Nos. 1 and 2 are devoted to an attempt to prove the hibernation of the insect in the chrysalis state. No. 3 advises as remedies hand-picking, fires at night, sowing castor-bean and cow-pea in the cotton field, and late fall and winter plowing].

Galveston News.—"The Cotton Caterpillar." September, 1879.

[Contains extracts from the report of Dr. G. E. Gillespie to Professor Riley, on hibernation and the encouragement of birds.]

Galveston News.—"The Cotton Worm Investigation." August 14, 1880.

[An interview between a reporter of the *News* and Professor Stelle on the work of the Commission].

Gaumer, Geo.—"Injury to Fruit." Kansas Farmer, October 3, 1877.

[Gives an account of injury to ripe peaches by *Aletia xylina* in Kansas.]

Gartenbau-Zeitung.—"Die Baumwollraupe." October, 1876.

[A short account in German of *Aletia argillacea* and *Laphygma frugiperda* (Graswurm). Illustrated.]

Glover, Townend.—"The Cotton Caterpillar (*Noctua xylina*)." Annual Report of the Commissioner of Patents (Agriculture), 1855, pp. 71–76.

[Gives popular descriptions of all states of the insect, and an historical account of its ravages. Details the remedies known. Figures all states.]

Glover, Townend.—Insects Injurious to Cotton Plants. No. 3. Cotton Caterpillar, or Cotton Army Worm (*Noctua* [*Anomis*] *xylina*) Say. Monthly Report of the Department of Agriculture, 1866, p. 331.

[Substantially the same article as that in the Annual Report for 1855; very few changes.]

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Glover, Townend.—Report of the Commissioner of Agriculture, 1867, pp. 58–61.
[Describes the Cotton Worm in all states, with good figures. Speaks of the northward migration of the moths, and of the great good done by the ants in destroying both the eggs and the larvæ. Gives a popular description also of what is evidently *Pimpla conquisitor*.]

Glover, Townend.—Report of the Commissioner of Agriculture, 1871, pp. 83, 84.
[Gives an account of the occurrences of the worm in 1871, and speaks without specific reference of a recently invented machine for sprinkling poisons. Advises strenuous efforts to destroy the first crop of worms.]

Glover, Townend.—Report of the Commissioner of Agriculture, 1872, pp. 118–120.
[An account of the ravages of the Cotton Worm in 1872.]

Glover, Townend.—Report of the Commissioner of Agriculture, 1873, pp. 163–169.
[Injuries in 1873; summary of experience in favor of the green.]

Glover, Townend.—Monthly Reports of the Department of Agriculture, 1874, p. 125.
[His belief quoted that the insect hibernates in all states in the more southern portions of the cotton belt, and as the season advances migrates northward.]

Glover, Townend.—Report of the Commissioner of Agriculture, 1874, pp. 128, 129.
[A review of Mr. Grote's paper on the migration of the Cotton Moth.]

Glover, Townend.—Manuscript Notes from my Journal—Cotton, and the principal Insects, &c., frequenting or injuring the Plant in the United States. Washington, 1878. (A few copies printed from stone for private distribution.)
[On plate x figures the Cotton Worm in all stages.]

Gorham, D. B.—"The Cotton Worm, its History, Character, Visitations, &c." De Bow's Commercial Review, iii, p. 535, 1847.

Reimpr.—Southern Cultivator, 1847, p. 114.

Reimpr.—De Bow's Industrial Resources of the Southern and Western States, 1852, p. 158.
[Contains an account of previous visitations of the Cotton Worm, and extended remarks upon its natural history. Proclaims the migration theory in full, and gives arguments for it. Draws up a description of what is evidently *Pimpla conquisitor* (the first mention of a parasite on the cotton worm).]

Grote, A. R.—Proceedings of the Entomological Society of Philadelphia, iii, p. 541, 1864.
[Announces the identity of *Noctua xylina* Say, and *Anomis bipunctina* Guenée, and proposes the name *Anomis xylina* Say.]

Grote, A. R.—"*Anomis xylina*. A Review." Rural Carolinian, iii, pp. 88–92, 1871.
[An extended criticism of a paper by Dr. Anderson's in vol. ii, p. 695. Gives a hint at the migration theory which he elaborates in 1874.]

Grote, A. R.—"Dr. E. H. Anderson and Cotton Caterpillars." Rural Carolinian, iii, pp. 306, 309, 1871.
[A review of Dr. Anderson's paper on pp. 204–207.]

Grote, A. R.—"*Anomis xylina* (Say)." Bulletin of the Buffalo Society of Natural Sciences, i, p. 170, 1874.
[First suggestion with a reservation that Hübner's *Aletia argillacea* is the same as Say's *Noctua xylina*.]

Grote, A. R.—"The Cotton Worm." American Naturalist, viii, p. 562, 1874.

Grote, A. R.—"On the Cotton Worm of the Southern States (*Aletia argillacea* Hübner)." Proceedings of the American Association for the Advancement of Science, xxiii, part ii, pp. 13–18, 1874.

Adv. pr.—Hartford Courant, xxxviii, No. 195.

Adv. pr.—New York Tribune Extra No. 21, pp. 61–62.

Adv. pr.—American Naturalist, viii, pp. 722–727.
[Habits and synonymy of the Cotton Worm. Proposes the migration theory. The final print, as published in the American Naturalist and the A. A. A. S. Proceedings, is altered and differs from the first print in essential particulars.]

Grote, A. R.—"The Cotton Worm; its Habitat. Means against it." Scientific American, xxxi, p. 168, 1874.

Grote, A. R.—"List of the Noctuidæ of North America." Bulletin of the Buffalo Society of Natural Sciences, ii, 1874–'75.
[On page 24, the Cotton Moth is entered under Hübner's name of *Aletia argillacea*, and its synonymy is given.]

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Grote, A. R.—"The Cotton Worm." Geological Survey of Alabama, Report of Progress for 1875. Montgomery, 1876, pp. 199–204.

[An account of the natural history of the Cotton Worm, with arguments favoring the migration theory.]

Grote, A. R.—"Report of A. R. Grote, of Buffalo, N. Y." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 351–352.

[A short account of Mr. Grote's doings in Georgia and Alabama as an observer in the investigation.]

Grote, A. R.—"The Cotton Worm." North American Entomologist, i, p. 68, March, 1880.

[A vain criticism of Bulletin 3, United States Entomological Commission.]

Grote, A. R.—"*Aletia argillacea*." In "North American Noctuidæ in the Zutræge." Canadian Entomologist, xii, p. 116, June, 1880.

[Gives his views on migration.]

Guenée, A.—Spécies général des Lépidoptères. Noctuélites. Vol. ii, p. 400; ibid., p. 401; vol. iii, p. 397; 1852.

[In vol. ii, p. 400, the Cotton Worm Moth is described as *Anomis grandipuncta*; on page 401 it is again described as *Anomis bipunctina*, and again, in vol. iii, p. 397, under the latter name (see Chapter I).]

Harris, T. W.—"A Treatise on some of the Insects of New England which are Injurious to Vegetation." Boston, 2d edition, 1852, p. 457.

[A very brief account of *Noctua xylina* Say.]

Harris, T. W.—"Entomological Correspondence." Boston, 1869, p. 169.

[In a letter to Doubleday mentions having received specimens of the moth and asks for a generic determination. Date of letter, October 24, 1846.]

Hempstead, O. H., jr.—"The Cotton and Boll Worm." Monthly Report of the Department of Agriculture, 1867, p. 214.

[Favorable experiences with home-made trap-lantern.]

Henderson, Stephen.—"The Army Worm." Farmers' Register (Va.), 1840, pp. 660–661.

[An interesting account of the ravages of *Anomis xylina* in Louisiana in 1840.]

Holly Springs South.—"A Committee of Entomologists." April 7, 1880.

[Announcement of a memorial presented to Congress by Hon. V. Manning, from the professors of the University of Mississippi, asking for a cotton-insect investigation.]

Howard, W. R.—"*Anomis* (*N*) *xylina*." Phillip's Southern Farmer, vii, pp. 361, 362, 1873.

[Gives a short account of the natural history of the Cotton Worm; states at length the conflict of opinion on the subject of the hibernation of the insect, quoting the opinions of all the prominent writers, and asking all planters to try and solve the problem.]

Howard, W. R.—"Cotton Worm." Phillip's Southern Farmer, November, 1874.

[Arguments in favor of the hibernation of the moth, and remarks upon patents for arsenical mixtures.]

Howard, L. O.—"A new Silk-spinning Chalcid." Canadian Entomologist, August, 1880, p. 158.

[Describes *Euplectrus comstockii* n. sp., a parasite on the Cotton Worm.]

Hoy, P. R.—"The Occurrence of *Aletia argillacea* in Wisconsin."

[Read before the Entomological Club of the American Association for the Advancement of Science. Saratoga meeting, 1880.]

Hoyt, J. D.—"Practical Modes of Destroying the Cotton Worm." Prize Essay. Selma, Ala., 1874.

[Paris green, arsenious acid, knocking the worms from the plants, fires, lantern traps.]

Hubbard, H. G.—"Notes on the Cotton Worm in Florida." American Entomologist, iii, p. 227, 1880.

Hubbard, H. G.—"*Phora aletiæ* not a true parasite." American Entomologist, iii, p. 228, 1880.

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Hubbard, H. G.—"Ants *vs.* Cotton Worms." American Entomologist, iii, p. 249, 1880.

Hubbard, H. G.—"Vertebrate Enemies of *Aletia*." American Entomologist, iii, p. 250, 1880.

Hubbard, H. G.—"Spider and Cotton Worm." American Entomologist, iii, p. 250, 1880.

Hübner, Jacob.—Zuträge zur Sammlung exotischer Schmetterlinge, bestehend in Bekundigung einzelner Fliegmuster neuer oder rarer nicht europäischer Gattungen, Augsburg, Verfasser. 1818–1823, Centur. ii.

[Contains the original description of *Aletia argillacea*.]

"Investigator."—"The Cotton Worm." Galveston News, September 9, 1879.

[Casts unwarranted reflections on the work of the Commission.]

Johnson, Cuthbert W.—Farmers' and Planters' Encyclopedia of Rural Affairs. London, 1843; Philadelphia, 1868.

[In article on "Cotton," quotes from Spalding's essay as in Ure.]

Jones, R. W.—"Boll-worm devouring Cotton-worm." American Entomologist, iii, p. 253, 1880.

Jones, R. W.—"Uselessness of Yeast Ferment." American Entomologist, iii, p. 296, 1880.

"J., W." (Wm. Jones?)—"The Cotton Caterpillar." Southern Cultivator, 1867, p. 167.

[Advises extermination of the first brood by destroying the eggs.]

Jones, Wm.—"Cut-worms and Caterpillars." Southern Cultivator, 1869, pp. 106, 107.

[Editorial answer to questions about Cotton Worm. Arguments for the hibernation of the chrysalis, and notes on extensive parasitism of the last brood of worms.]

Jones, Wm.—"The Cotton Caterpillar." Southern Cultivator, 1870, p. 67.

[Editorial answer to letter from A. S. M., asking for information concerning Cotton Worms. States that little is known, and dwells upon disputed point of hibernation.]

Jones, Wm. J.—"The Cotton Caterpillar." Galveston News, August 19, 1879.

[A long article advocating hibernation of the pupa.]

Jones, Wm. J.—"The Cotton Caterpillar Question." Galveston News, October 31, 1879.

[A controversial answer to Professor Riley's letter, published in the *News* of October 24, 1879.]

Jones, Wm. J.—"Report of Judge Wm. J. Jones, of Virginia Point, Texas." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 356-358.

[Judge Jones's account of observations during 1878.]

Jones, Wm. J.—"London Purple in Texas." American Entomologist, iii, p. 251 1880.

"K."—"How to destroy Caterpillars." Southern Farm and Home, 1871, p. 135.

[Believes that the webs on trees through the winter contain the germs of the cotton worms. Hence, advises to burn all such webs.]

Kellicott, D. S.—"Aletia in New York State." American Entomologist, iii, p. 297, 1880.

[Specimens found October 16, 1878, and November 6, 1880.]

Landon, M. D.—"The Cotton Caterpillar (*Noctua xylina*)." Report of the Commismissioner of Agriculture, 1864, p. 90.

[A short account of the natural history of the insect, with figures of larva, chrysalis, and moth. Advocates the hibernation of the moth.]

Legree, J. D.— Southern Agriculturist, 1829, p. 427.

[In a foot-note to an article on rotation of crops, advises rotation of crops for Cotton Caterpillar, and also warns against the injudicious use of manure in a state of fermentation.]

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Lintner, J. A.—"Entomology in America in 1879." Address of the President of the Entomological Club of the American Association for the Advancement of Science. American Entomologist, iii, p. 16, 1880.

[Gives a long notice of Glover's Manuscript notes —, Cotton, and cites it as a model.]

Loring and Atkinson.—Cotton Culture and the South. Boston, 1869.

[On p. 64 gives a very meager notice of the Cotton Worm.]

Lyman, Joseph B.—"Cotton Planting." Report of the Commissioner of Agriculture, 1866, p. 193.

[Under the head of "Enemies of the Cotton-Plant, and how to destroy them," the Cotton Moth is described. Advises sugaring for the moths, fires at night, catching the moths in hand-nets, and picking the leaves on which the eggs are deposited. The article contains some glaring errors.]

Lyman, Joseph B.—Cotton Culture. New York, Orange Judd & Co., 1868. "The Cotton Moth," pp. 86–89.

[A short account of the metamorphoses, with figures of the different stages.]

"M."—"The Cotton Moth." American Agriculturist, vi, p. 22, January, 1847.

[Effect of weather on the period of development and number of broods; hypothetical biography of *N. xylina*.]

McCook, H. C.—"Formicariæ." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 182–189.

[A short report upon the species of ants collected by the observers connected with the Cotton Insect Investigation. Treats of (1) *Dorymyrmex insanus* (Buckley), (2) *D. flavus*, n. var., (3) *Iridomyrmex maccooki* Forel, (4) *Crematogaster lineolata* (Say), (5) *C. clara* Mayr, (6) *Solenopsis xyloni* n. sp., (7) *Monomorium carbonarium* Smith, and figures nos. 1, 4, and 6.]

"McG."—"Diseases of the Cotton Plant and their Remedy." De Bow's Review, xi, p. 7, 1857.

Reimpr.—De Bow's Industrial Resources of the Southern and Western States. 1852, p. 158.

McKinnen, Daniel.—Tour through the British West Indies in 1802–'3. Giving a Particular Account of the Bahama Islands. London, 1804.

[Gives an account of the ravages of the *chenille* on Acklin's Island, Bahamas, and also of the appointing of a commission by the general assembly of the islands, in 1801, to investigate the causes for the repeated failure of the cotton crop, the principal cause being the ravages of the *chenille*.]

Macon Telegraph and Messenger.—"The Cotton Caterpillar." July 29, 1880.

[Contains a press report of Professor Riley's Mobile Cotton Exchange address, and also prints in full Circular No. 11 of the Commission.]

Marion (Ala.) Commonwealth.—"Prof. C. V. Riley." July 3, 1879.

[Editor's notice of Professor Riley's views on hibernation and announcement of the proposed investigation.]

Mobile Register.—"The Cotton Caterpillar." August 18, 1872.

Reimpr.—Carolina Farmer, September, 1872.

Reimpr.—Southern Farm and Home, October, 1872.

[An editorial on this subject, mentioning in the concluding paragraph the fact that Paris green was being used by several persons at that time.]

Mobile Register.—"The Cotton Worm." June 2, 1880.

[Editorial notice of the United States Entomological Commission and a lengthy plea for extended appropriations.]

Montgomery (Ala.) Advertiser.—"Cotton Caterpillar." August 15, 1873.

[Detailed experiments on the breeding of *Aletia* in jars.]

Morrill, Augustus (United States Consul at Manzanillo, Mexico).—"Cotton Culture and the Cotton Worm at Manzanillo, Mexico." American Entomologist, iii, p. 152, 1880.

Morrison, H. K., and Hagen, H. A.—"Is *Aletia argillacea* winter-killed every year?" Psyche, ii, p. 23, March–April [9 July] 1877.—Psyche Record, No. 1381.

[Support the negative of the question.]

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Morse, George W.—"The Cotton Caterpillar." Monthly Reports of the Department of Agriculture, 1867, p. 249.

[Advises that summary measures be taken to destroy the first brood of worms by offering a reward for the first worm, and as soon as that is found turning a force into the fields to search for them.)

Motheral, W.—"The Cotton Worm." Rural Sun, Nashville, Tenn., February 25, 1875.

[Gives an incomplete account of the natural history and advises the introduction of the English Sparrow into the South.]

Mullen, S. B.—"Stink Bush as an Insecticide." American Entomologist, iii, p. 228, 1880.

[Advises its use for *Aletia*.]

Natchez Democrat and Courier.—September 7, 1880.

[A short article (editorial) on London purple and Pyrethrum.]

New Orleans Picayune.—"The Cotton Worm Commission." August 13, 1878.

[Editorial notice of the organization of the investigation with an explanation of the migration theory.]

New, W. W.—Southern Planter, 1842.

[In an address before the Agricultural Society of Hinds County, Mississippi, 1839, advises planting cotton in hills, giving the plant more light and sun and lessening the protection of the insect.]

Our Home Journal and Rural Southland.—"The English Sparrow—A remedy for the Cotton Worm." 1873.

Packard, A. S., jr.—"Guide to the Study of Insects." Salem, 1869, pp. 313–315. *A. xylina*.

[Short account of natural history and habits.]

Packard, A. S., jr.—"The Cotton Army Worm, *Aletia argillacea* Hübner; *Anomis xylina*, Say." Report on the Rocky Mountain Locust and other Insects now injuring or likely to injure Field and Garden Crops in the Western States and Territories. Extracted from the Ninth Annual Report of the United States Geological and Geographical Survey of the Territories for 1875, pp. 775–778.

[A general account of the insect, compiled from Riley, Grote, and Glover.]

Packard, A. S., jr.—American Naturalist, xiv, p. 535, 1879.

[Editorial notice of the transfer of the Cotton Worm Investigation from the Agricultural Department to the United States Entomological Commission.]

Packard, A. S., jr.—"Riley on the Cotton Worm." American Naturalist, xiv, p. 283, 1880.

[Notice of Bulletin 3, United States Entomological Commission.]

Packard, A. S., jr.—American Naturalist, xiv, p. 753, 1880.

[Editorial account of the organization of work on the Cotton Insect Investigation for 1880.]

Phares, D. L.—"The Cotton Army Worm (*Anomis xylina*, Say)." American Entomologist, i, p. 242, 1869.

[States that the insect hibernates as a moth, and describes the egg. Advocates hand-picking if it can be done by concerted action on the part of the planters. Advises also sugaring and fires in May or June.]

Phares, D. L.—"The Cotton Caterpillar (*Anomis xylina*)." Lecture delivered before the Farmers' Club of Woodville, Miss., May 4, 1869; abstract published in Rural Carolinian, i, pp. 683, 695, August, 1870.

[This article is accompanied by a full page lithograph of cotton-stalk infested by larva, chrysalis and adult, and engravings of the Cotton Worm (*Anomis xylina*), the Boll Worm (*Heliothis armigera*), and the Grass Worm (*Laphygma frugiperda*) in all stages. The article has the following heads: History. Will the caterpillar cause cotton culture to cease? Why is the caterpillar worse some years? Errors. Proposed modes of destroying. Propagation.]

Philips, M. W.—"The Cotton Worm." Southern Cultivator, 1848, p. 28.

[Quite an extended article, giving a description of the larva and chrysalis.]

Porter, Geo. R.—Tropical Agriculturist. London, 1833.

[On p. 24, in speaking of cotton in Guiana, he copies part of Chisholm's article on the *chenille*.]

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"R."—"Chrysalis—Paris Green—Professor Riley—Cavalry—Infantry." Selma (Ala.) Times, August 7, 1874.

[Paris green, arsenious acid, patent pumps, and hand-picking the pupæ discussed.]

Read, John E.—Farming for Profit. Philadelphia, 1880.

[On p. 285 speaks of Cotton Caterpillar and advises the use of Paris green with precautions.]

Reese, W. P.—"Paris Green and the Cotton Caterpillar." Rural Carolinian, December, 1873.

[A short note, preliminary in its nature.]

Reese, W. P.—"The Cotton Caterpillar Again." Rural Carolinian, v, pp. 565, 566, 1874.

[The cotton worm said to hibernate in the chrysalis state under leaves, &c.; hence, as a remedy, burn leaves in fall. Also gives formula for use of Paris green in solution.]

Riley, C. V.—"The Cotton Army Worm (*Anomis xylina*, Say)." Second Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri, 1870, pp. 37–41.

[An account of the habits and natural history of the insect, with popular descriptions of all stages and figures of eggs, larva, chrysalis, and adult.]

Riley, C. V.—"Remedy for the Cotton Army Worm." Proceedings of the National Agricultural Congress; Indianapolis meeting, 1873.

[Urgently advises the use of Paris green.]

Riley, C. V.—"Remedy for Cotton Worm." Read at National Agricultural Congress, Indianapolis, 1873. (First printed in *Illustrated Journal of Agriculture*, Saint Louis, June, 1873; copied by *Rural World, Rural Alabamian, Mobile Register, Farmers' Advocate*, and other Southern periodicals.)

[Recommends Paris green.]

Riley, C. V.—"A Remedy for the Cotton Worm." Vicksburg Herald, May 1, 1874, from the New York Tribune.

[Paris green.]

Riley, C. V.—"The Cotton Worm." Sixth Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri. 1874. pp. 17–24.

[This article has the following heads: Paris green; Patents on the Paris green mixture; Hibernation of the insect; Natural enemies; Range of the insect; Other questions.]

Riley, C. V.—"Insects affecting the Cotton Plant." Report of the Commissioner of Agriculture, 1878.

[A short report on the progress made in the Cotton Insect Investigation; embodies a report by A. R. Grote.]

Riley, C. V.—"Cotton Worm." Atlanta Constitution, September 8, 1878.

[Contains first published suggestion that the moths feed from the extra-floral nectar glands.]

Riley, C. V.—"The Migrations and Hibernation of *Aletia argillacea*."

[Read before 1879 meeting of the National Academy of Sciences.]

Notice of the same.—Washington World, May 10, 1879.

Notice of the same.—Science News, June 1, 1879.

Notice of the same.—Scientific American, June 14, 1879.

[Reviews the different hibernation theories, and states his belief in the hibernation of the moth in certain southern parts of the Cotton Belt.]

Riley, C. V.—"The Cotton Worm." Mobile Register, July 9, 1879.

[Report of a lecture before the Cotton Exchange, in which mention was first made of the relation of the natural enemies to the wet-weather abundance and dry-weather scarcity of the cotton worm.]

Riley, C. V.—Review of National Academy paper. American Naturalist, xiii, p. 726, 1879.

Riley, C. V.—"Parasites of the Cotton Worm." Canadian Entomologist, xi, p. 161. September, 1879.

[Describes *Trichogramma pretiosa* n. sp., *Cirrospilus esurus* n. sp., and *Tachina aletiæ*, n. sp.]

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Riley, C. V.—"The Cotton Worm in the United States." Proceedings of the American Association for the Advancement of Science, xxviii. Saratoga meeting, 1879.
[Brings forward arguments against the migration theory and gives recent discoveries made in the course of the official investigation.]

Riley, C. V.—"The Cotton Worm in the United States." Abstract of a paper read before the Saratoga meeting of the American Association for the Advancement of Science. American Entomologist, iii, p. 93, 1880.
[Refutes Grote's migration theory.]

Riley, C. V.—"The Cotton Worm." Galveston News, October 24, 1879.
[An answer to W. J. Jones and to the charges of "Investigator."]

Riley, C. V.—"On the Hibernation of the Cotton Worm." From advance sheets, Bulletin 3, United States Entomological Commission. American Entomologist, iii, p. 6, 1880.
[A long article favoring the hibernation of a small percentage of the moths in the more southern portions of the Cotton Belt.)

Riley, C. V.—"Two valuable Insecticides." American Entomologist, iii, p. 41, 1880. From advance sheets, Bulletin 3, United States Entomological Commission.
[London purple and Pyrethrum.]

Riley, C. V.—"The Cotton Worm." Bulletin 3, United States Entomological Commission. Department of Interior. Washington, 1880.
[A paper-covered volume of 144 pp., one colored plate and many wood-cuts.]

Riley, C. V.—"A new Genus of Proctotrupidæ." American Entomologist, iii, p. 52, 1880.
[Describes *Didyctium* n. g., *zigzag* n. sp., a parasite of the Cotton Worm.]

Riley, C. V.—"Cotton Caterpillars." Selma Times, June 25, 1880.

Riley, C. V.—"How to manage the Cotton Worm. Suggestions to Cotton Planters." Farmers' Review, July 8, 1880.

Riley, C. V.—"The Cotton Worm." American Entomologist, iii, p. 67, 1880.
[From Bulletin 3, United States Entomological Commission.]

Riley, C. V.—"Sowing Cotton Seeds in hot beds and transplanting as a means of preventing injury from the Cotton Worm." American Entomologist, iii, p. 107, 1880.
[Suggestion disapproved on account of difficulty of transplanting without injury.]

Riley, C. V.—"Cotton Culture and the Insects injuring the plants at Bahia, Brazil." American Entomologist, iii, p. 128, 1880.
[Contains a letter from R. A. Edes, United States Consul at Bahia.]

Riley, C. V.—"Early appearance of the Cotton Worm." American Entomologist, iii, p. 149, 1880.
[Appearance of the worms in 1880 noted on April 29 and May 8.]

Riley, C. V.—"Sprinklers and Atomizers." American Entomologist iii, p. 185–211, 1880.
[Principally extracted from Bulletin 3, United States Entomological Commission.]

Riley, C. V.—"Supplementary Instructions to Agents of the United States Entomological Commission." American Entomologist, iii, p. 218, 1880.

Riley, C. V.—"The Cotton Destroyers." New Orleans Democrat, September 21, 1880: Selma Times, September 29, 1880.
[A long letter to the Democrat with the subheads: *Principles established; The best poisons; London purple; Pyrethrum; Oils; Improved appliances; Poisoning from below; Early poisoning; Weather; Conclusions.*]

Riley, C. V.—"Additional Experiments with Pyrethrum." American Entomologist, iii, p. 242, 1880.
[An account of experiments upon Cotton Worms made by Mr. H. G. Hubbard.]

Riley, C. V.—"Insecticides now in use in the South for the Protection of Cotton." American Entomologist, iii, p. 245, 1880. From the Scientific American.

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Riley, C. V.—"Synonyms of Parasites; Mistakes corrected." American Entomologist, iii, p. 293, 1880.

[States *Didyctium zigzag*—a supposed cotton-worm parasite—to be a *Hexaplasta*; also surmises it to be a parasite of *Phora aletiæ*, and not of *Aletia* itself.]

Riley, C. V.—Answers to Correspondents concerning Cotton Worm inquiries; also, small notes there-anent. American Entomologist, iii, pp. 107, 108, 129, 154, 181, 204, 205, 206, 228, 278, 1880.

Riley, C. V.—"Cotton Worms and Cicadas, Professor Stelle's Logic." Selma Times, July 19, 1881.

[A controversial answer to certain publications of Professor Stelle's, and especially to that in the Mobile Register of January 15, 1881.]

Riley, C. V.—"Hibernation of the Cotton Worm Moth; Ease with which mistakes are made." American Naturalist, xv, p. 244, March, 1881.

[A correspondent mistakes *Leucania unipuncta* for Aletia.]

Riley, C. V.—"Notes on North American Microgasters, &c." Transactions of the Academy of Science of Saint Louis, iv, No. 2, April 16, 1881.

[On pp. 3, 11, and 12 treats of *Apanteles aletiæ*, a new species parasitic upon the Cotton Worm.]

Riley, C. V.—"Moths Mistaken for Aletia." American Naturalist xv, p. 486. June, 1881.

[*Platyhypena scabra* and *Phoberia atomaris*.]

Riley, C. V.—"The Cotton Worm." Address of Hon. Geo. B. Loring, and other Proceedings of Cotton Convention held at Atlanta, Ga., November 2, 1881. Government Printing Office. 1881.

[A lengthy address devoted principally to a description of improved machinery for the destruction of the worms.]

Report of same address.—Atlanta Constitution, November 5, 1881.

Say, Thomas.—"Correspondence relative to the Insect that destroys the Cotton Plant." Southern Agriculturist, i, p. 203. 1828.

Reimpr.—New Harmony Disseminator. 1830.

Reimpr.—Transactions of the Agricultural Society of the State of New York, 1857. p. 883.

Reimpr.—Say's Entomology of North America. Ed. Le Conte, i. pp. 369, 381, 1859.

[Consists of a letter from C. W. Capers to Thomas Say, transmitting specimens of the cotton worm, and Say's reply, describing the insect as *Noctua xylina*.]

Schwarz, E. A.—Colorado Citizen, September 9, 1879.

[A short letter defending Professor Riley against the charges of "Investigator."]

Schwarz, E. A.—"Report of E. A. Schwarz, of Washington, D. C." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 347–350.

[An account of Mr. Schwarz's trip to the Bahamas in search of Aletia, together with "Remarks on the Hibernation of Aletia."]

Schwarz, E. A.—"Biological Note on *Euplectrus comstockii* Howard." American Naturalist, p. 61, January, 1881.

[Gives habits of this Cotton Worm parasite.]

Reimpr.—Naturalists' Leisure Hour, January, 1881.

Scientific American.—"A Probable Cure for Cotton Worm." October 26, 1878.

[Editorial notice of the discovery by Riley that the moths feed on the foliar glands.]

Seabrook, Whitemarsh B.—A Memoir on the Origin, Cultivation, and Uses of Cotton, from the Earliest Ages to the Present Time, with Especial Reference to the Sea Island Cotton Plant, including the Improvements in its Cultivation, and the Preparation of the Wool, &c., in Georgia and South Carolina. Read before the Agricultural Society of St. Johns, Colleton, November 13, 1843, and the State Agricultural Society of South Carolina, December 6, 1843, and by both societies ordered to be published. Charleston, 1844.

[On pp. 42–45 is a short historical sketch of the "caterpillar (Noctua xylina), with an account of the methods used in Colleton County to exterminate them; also some remarks upon the natural history of the insect.]

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Seabrook, W. B.—"The Cotton Caterpillar." American Farmer, ii, 308. 1847. From the Charleston Mercury.

[States that he does not believe in the hibernation of the moth.]

Selma Times.—"The Cotton Worm Investigation." Editorial in Selma Times, July 21, 1880.

Reimpr.—American Entomologist, iii, p. 197 (1880).

Selma Times.—"Hogs as Destroyers of the Cotton Caterpillar." September, 1878.

Southern Cultivator.—"Cotton Caterpillar." 1846, p. 157.

Southern Cultivator.—"The Cotton Worm; its History, Character, Visitations, &c." 1847, p. 137.

[Editorial answer to Dr. Gorham's migration theory.]

Southern Cultivator.—"Destroying the Cotton Moth." viii, p. 132, 1850.

[Advocates "sugaring" for the moth with molasses and vinegar.]

Southern Cultivator.—"The Caterpillar." 1869, p. 13.

[Advocates hand-picking as the only sure remedy.]

Southern Cultivator.—"The Cotton Worm." 1869, p. 18.

[Advises the use of Dr. Heard's moth-trap.]

Spalding, Thomas.—"The Cotton Caterpillar." American Farmer, ii, p. 283, 1847. From the Savannah Republican.

[Advocates burning all rubbish in the spring, destroying the moths before they lay their eggs.]

Stelle, J. Parish.—"Southern Notes. The Coming Cotton Worm." American Entomologist and Botanist, ii, p. 124, 1870.

[States that the worm is always worse after a mild winter. Gives differences between "grass worm and cotton worm."]

Stelle, J. Parish.—"The Cotton Caterpillar." The Rural Alabamian, i, pp. 78–80, 1872.

[Arguments to prove that the ravages of the Cotton Worm are worse after a severe winter than a mild one. A description of the moth and notes upon the habits of the worm. Hand-picking and fires are advised as remedies.]

Stelle, J. P.—"The Cotton Caterpillar. All about how to save the Cotton Crop." Mobile Register, July 5, 1873.

[Gives figures of the insect and describes all stages, with a short account of habits. Strongly advises the use of Paris green. Quotes from Riley's paper and says that he himself tried experiments the previous year with the poison.]

Stelle, J. P.—"That Patent on Paris Green." Mobile Weekly Register, November 21, 1874.

[Contains a lengthy and interesting correspondence between J. P. Stelle and W. B. Royall, relative to the ground covered by Royall's patent.]

Stelle, J. P.—"The Cotton Caterpillar and how to combat it successfully." Rural Carolinian, v, pp. 511–515, 1874.

[An account of habits, with description and figures of the insect in all stages. Advises the use of Paris green. Gives the formula for the Texas Cotton Worm Destroyer.]

Stelle, J. P.—"Ants *vs.* Aletia again." American Entomologist, iii, p. 251, 1880.

Stelle, J. P.—"Road Dust *vs.* Cotton Worms." American Entomologist, iii, p. 252, 1880.

Stelle, J. P.—"The Cotton Worm." Southern Farmers' Monthly, June, 1880.

Stelle, J. P.—"To save the Cotton." Mobile Register, September 4, 1880.

[Paris green and London purple, a long editorial.]

Stelle, J. P.—"Cotton Worms in Mexico." Mobile Register, February 12, 1881.

[Quotes the letters of S. T. Trowbridge, United States Consul at Vera Cruz, and R. de Z. Enriques of the same place; and quotes Professor Riley's comments in the American Entomologist.]

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Stelle, J. P.—"The Cotton Worm Investigation." Mobile (weekly) Register, January 15, 1881.

Reimpr.—Southern Farmers' Monthly, April, 1881.

Reimpr.—Galveston News, August 4, 1881.

[Summary of results of Commission work.]

Stelle, J. P.—"Killing Cotton Worms." From Mobile Register. Selma Times, July 18, 1881.

[A long article with the following subheads: *Our native plants; Pyrethrum; London Purple; Paris Green; Arsenic.*]

Stelle, J. P.—"To save the Cotton Crop." Galveston News, August 19, 1881.

[London purple.]

Taylor, P. G. H.—"A Remedy for the Caterpillar." Southern Cultivator, 1871, p. 385.

[Advises the use of arsenic in solution.]

Texas Journal of Commerce.—"More about the Cotton Worm." July 31, 1880.

[Editorial mention of letters from Professor Riley, and quotes in full Circular 11, United States Entomological Commission.]

Thaxter, R.—Psyche, ii, p. 37, May-June [9 July], 1877.

[Says that Aletia occurs about Newton, Mass., rarely at light in September.]

Trelease, Wm.—"Report of Wm. Trelease, of Brooklyn, N. Y." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 361–379.

[An extended discussion of the natural history of Aletia and Heliothis, embodying all of his observations made in Alabama in the summer of 1879.]

Trelease, Wm.—Psyche, iii, p. 186, March [25 July], 1880.

[Report of meeting of Cambridge Entomological Club, in which Mr. Trelease stated that the moths (*Aletia*) seek the extra-floral glands on the peduncle of the sweet-potato plant for food.]

Trowbridge, S. T., and Enriquez, R. de Z.—"Interesting Cotton Worm Notes from Vera Cruz." American Entomologist, iii, p. 179, 1880.

Turner, J. A.—The Cotton Planter's Manual. New York, 1857.

[Quotes Dr. Gorham's article.]

Upton, Wheelock S.—"The Cotton Caterpillar." De Bow's Review, ii, p. 354, 1846.

[Advises soaking seeds of cotton in a solution of bluestone as a preventive.]

Ure, Andrew.—History of the Manufacture of Cotton. London, 1836.

[On pages 156 and 174 of vol. i, are given accounts of the *chenille* in British Guiana, and on the Sea Islands of Georgia (short and of little value).]

Wailes, B. C. L.—"The Cotton Plant; its Origin and Varieties, and its Enemies and Diseases." In Wailes' Agriculture and Geology of Mississippi, first report, 1854, pp. 146–148.

[A short sketch of the Cotton Worm, which he calls *Depressaria gossypioides*. Advises, as a remedy, attracting the moth by fires.]

Waldo, J. Curtis.—The Cotton Worm. A Treatise on the Enemy of the Great Staple, with the Practical Experience of many of the most intelligent Planters of the South as to the means of destroying the worm. New Orleans, 1878.

[*History of the Cotton Worm; How they look; Preventives; Jute as a preventive; Destroyers of the Cotton Worm.*]

Walsh, B. D., and Riley, C. V.—"Entomological Ignorance in the South." American Entomologist, i, pp. 14–16, 1868.

[A severe criticism of an article then going the rounds of the Southern press, headed, "How to destroy the Cotton Worm—a Suggestion."]

Walsh, B. D., and Riley, C. V.—"Cotton Insects. The Cotton Army Worm (*Noctua* [*Anomis*] *xylina*, Say)." American Entomologist, i, pp. 209–212, 1869.

[An account of the transformations of the Cotton Worm, with figures and descriptions of each stage. Hand-picking, destroying the moths by fire, and sprinkling the plants with cresylic soap solution, are advised as remedies.]

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Walsh, B. D.—"The Three So-called Army Worms." Practical Entomologist, i, p. 112, 1866.

Wells.—Year Book of Agriculture, 1855.
[Figures the Cotton Army Worm.]

Wetherby, A. G.—Report of the Proceedings of the Entomological Club of the American Association for the Advancement of Science. Nashville meeting, 1877. Canadian Entomologist, ix, p. 172, 1877.
[A discussion on the migration theory, by Grote and others.]

Willet, J. E.—"Report of Prof. J. E. Willet, of Macon, Ga." Report upon Cotton Insects, Department of Agriculture, 1879, pp. 358–361.
[Professor Willet's report of observations during 1878.]

Willet, J. E.—"Experiments with Yeast Ferment on Cotton Worms." American Entomologist, iii, p. 289, 1880.

Williams, Wm. H.—"Why the Cotton Worm thrives South." Rural New-Yorker, August 17, 1872.
[Advises poisoned muskmelons to attract moths.]

Winfree, P.—"The Cotton Caterpillar." De Bow's Review, iv, p. 251, 1847.
Reimpr.—De Bow's Industrial Resources of the Southern and Western States, p. 172, 1852.
[Uses arguments against Dr. Gorham's migration theory. Gives personal experience with the Cotton Worm in the Bahamas a few years previous.]

Witting, Geo.—"Capture of the Cotton Moth in January." American Entomologist, iii, p. 152, 1880.

Youmans, E. L.—"Investigating the Cotton Worm." Popular Science Monthly, xiv, p. 406, January, 1879.
[Editorial notice of Mr. Grote's expedition South, and explanatory of the migration theory.]

"Zenos."—"The Cotton Caterpillar." Southern Cultivator, 1868, p. 298.
[An account of the natural history of the insect. States that the last brood winters in the chrysalis state, underground, and advises winter plowing.]

Zimmerman, J. H.—"The Cotton Worm; its Character, Habits, etc." American Cotton Planter, August, 1855 (from De Bow's Review).
[Gives an account of the metamorphoses of the Cotton Worm and Boll Worm. Advises as remedies rotation of crops and sugaring for the moths.]

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CHAPTER XV.

INSECTS LIABLE TO BE MISTAKEN FOR ALETIA.

In the course of the Cotton Worm investigation, confusion has many times arisen from the inability of observers, not practiced entomologists, to distinguish Aletia from a number of allied Noctuids. In the first edition of this work the case was especially mentioned of *Aspila virescens*, the pupæ of which were plowed up in large numbers and mistaken for Aletia. Other pupæ of allied species are in like manner often mistaken for those of the Cotton Worm. There are a number of Noctuid moths which have been frequently sent to us during the winter as true Aletias and as furnishing proof of the hibernation of this last. In this chapter we desire to illustrate the characters of the most important, such as those already mentioned in discussing the question of hibernation (pp. 17–19), and to give, also, the life-histories of two species of the genus *Anomis* which so much resemble Aletia in their earlier states that the unpracticed eye has great difficulty in distinguishing them. One of the species, so frequently mistaken for Aletia in its pupa and imago states, is the Boll Worm moth (*Heliothis armigera* Hübn.), but as this species is considered at length in Chapter XVI of this report, we need not refer to it more fully in the present chapter. The other species which we shall consider in this connection are: *Anomis erosa*, *A. exacta*, *Leucania unipuncta*, *Aspila virescens*, *Drasteria erechtea*, *Laphygma frugiperda*, *Platyhypena scabra*, and *Phoberia atomaris*.

ANOMIS EROSA Hübner.

[Plate II, Figs. 1, 2, 3.]

The following account of this species was published in our annual report as Entomologist of the Department of Agriculture for 1881–'82, and gives in sufficiently condensed form the facts which we wish to use here. Detailed figures of all states are there given in wood-cut:

"Of the numerous insects, the history of which we have traced in the last few years, one species of considerable interest may here be recorded; for it is not only interesting on account of its occurrence upon a fiber-producing plant, which some day may prove of considerable importance, but also on account of its relations to the Cotton Worm (*Aletia xylina*), for which it might easily be mistaken in its earliest stages.

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"The species under consideration appears to be quite generally distributed over most of the Gulf States wherever its food-plant (*Urena lobata*), and possibly other nearly related plants, are found growing.

"The belief that the eggs of the species now under consideration were those of Aletia was strengthened in the minds of those who first found them by the inference that after the disappearance of cotton, Aletia would have to search for other suitable plants to sustain its offspring until new cotton should commence to grow the following spring; but, so far, neither its eggs nor its larvæ have ever been discovered upon any other plant than cotton.

"The eggs of this Anomis, which so far have been found only on the leaves of Urena, appear, if examined with a common hand-lens, to be structurally indistinguishable from those of Aletia, and were sent to the Department from Florida by Dr. J. C. Neal, with the assurance that they really belonged to that insect, and that its winter food-plant was discovered. An examination under the microscope, however, showed considerable differences, notwithstanding the great similarity in size and sculpture. The color is, moreover, paler, and not of the peculiar bright-green characteristic of Aletia, and it is by this character that the egg of the Anomis may be distinguished from the other, when fresh, by the ordinary observer.

"The radial ridges are more numerous, ranging between 35 and 40, and the transverse ribs from 12 to 14. The radiating ribs of the Aletia egg are considerably rounded, with the spaces between them rather narrow, appearing like deeply-impressed striæ, while the ribs of the Anomis egg are sharp and triangular if viewed from above, with the spaces between them shallower and broader. The intersection of the transverse with the radial ribs of Aletia are not sharp, and are only marked by low, rounded elevations. Another quite marked feature of the eggs of Aletia is the arrangement of the radial ribs in five groups, connected with each other by an elevated ridge which forms around the center a large pentangular cell, into each angle of which one of the radial ribs terminates, the other ribs between them being somewhat shorter and connected by the terminal transverse rib. This arrangement is quite noticeable in fresh eggs, but still more in dry ones. The radial ribs in this Anomis, however, are not arranged in separate groups, and the longest ones surround the center in a perfect circle without terminating in a circum-central rib.

"This Urena Anomis is exclusively a Southern species, and it continues breeding with scarcely any intermission throughout the whole year. Moths have been captured in various parts of the South from August, throughout the winter, till May, and the eggs and larvæ of different sizes are found in Florida throughout the winter.

"The general habits of the larvæ are quite similar to those of Aletia, though as a rule the Anomis larvæ are less active, especially after they have attained one-half their growth. The newly-hatched larvæ

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are almost indistinguishable from those of Aletia, both being of the same size and of the same pale color. The former may, however, be at once recognized by the first and second pairs of prolegs being entirely obsolete, whereas, notwithstanding their minute size, the second pair is always present in Aletia. In this stage the larvæ are most active and nervous, and are usually found feeding on the lower side of the leaves, which they resemble so much in color that it is difficult to detect them when at rest.

"They stretch to their fullest length when resting, but very often may be seen in a position similar to that of the larvæ of Geometrids, and will then, if disturbed, leap from their hold and hang suspended by a thread, which, after a short rest, they will climb with great rapidity. The mode of climbing is very interesting. The head is suddenly bent downward, first to one side and then to the other, and each time the thread is grasped with the thoracic legs when the head is lowest. Growing larger, they become more and more sluggish, and can seldom be induced to spin, but usually hold to the leaf very tenaciously, so that some force is needed to remove them. If disturbed they will try to escape in a looping gait which is similar to that of Aletia. The full-grown larvæ usually assume a very peculiar position when at rest. The body is bent at about the middle in such a way that both halves lie close to each other so as to form a long and narrow loop, and the larva remains in this position sometimes for hours.

"The principal time of feeding, as observed in the vivarium, appears to be at night, and the larva usually rests during the day on the lower side of the leaves. The smaller larvæ eat only the softer parts, leaving the ribs untouched, but the older ones gnaw large irregular portions from the edge of the leaves, and will often consume two-thirds of a leaf in a single night. They also have the habit of devouring their own cast skins, sometimes not even leaving the head, and the newly-hatched worms will frequently feed upon the empty egg-shells before attacking the leaf. We have in one instance, however, observed a young larva which had only partly issued from the egg already at work gnawing the leaf.

"In March last [1882] we still found the larvæ of all sizes on the Urena around Crescent City, Fla., but failed to find any trace of them on any other plant. This has also been the experience of Messrs. Neal and Hubbard, who were instructed to make observations on this point.

"The moth (Plate II, Fig. 3) was first figured by Hübner (Zutr., 287, 288), and is fully described under the name of *Cosmophila erosa*,* by Guenée, who describes the larva in a few words and gives its food plant as *Hibiscus*. It occurs in South America, the specimens from Brazil being darker and brighter than ours, according to Guenée. The many specimens we have bred and captured show comparatively little variation., The color of the basal half of the front wing is bright yellow,

*Hist. Gen. d. Ins. Lép., Noctuélites, II, p. 395.

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speckled more or less intensely with ferruginous or brown. The posterior half is deeper, with olivaceous and brown shades, and with more or less of lilaceous. The hind wings are dull-yellowish, more or less shaded with reddish brown. The markings are withal so unique, as shown in the figure, that the species cannot well be confounded with any other.

"During winter the time elapsing from hatching to maturity has averaged, in our vivaria, about seven weeks, but development will be much more rapid during summer.

"Should the Urena ever be cultivated for its fiber, this its chief enemy will readily be destroyed by the same methods recommended against the Cotton Worm.

"DESCRIPTIVE.

"ANOMIS EROSA, Hüb.—*Egg.*—Diameter 0.8^{mm}, circular, flat below; the upper surface varies somewhat in convexity, in some being almost hemispherical, whilst with others it is quite flat, in general shape and size reminding one of the egg of *Aletia xylina*. Color, pale yellowish-green, almost of the same shade as the lower side of the leaves. The number of ribs which run from the base toward the summit varies in different eggs from 31 to 38. Of these ribs from 11 to 13 reach to about one-fourth the distance above the base, 5 to 7 half way toward the summit, and 16 to 18 to near the summit. The space between these ribs is divided quite constantly by 12 low transverse ribs, which at the intersection with the radiating ribs form a small though quite sharp triangular point, which is especially conspicuous in the empty egg. The spaces between these ribs form shallow, squarish depressions, which are finely granulated. The summit is almost smooth, surrounded with three series of small, roundish cells, which become larger away from the center, and beyond these another series of three rows of larger cells of different shapes, though more or less squarish.

"*Larva* (Plate II, Fig. 1).—*First stage.*—Length of the newly-hatched larva, 2^{mm}. Color very pale greenish-yellow along the dorsum, white and transparent toward the sides; head pale yellowish, without any markings; eyes black, tips of mandibles brown. Antennæ short, 3-jointed; first joint stout, very short and somewhat conical; second joint longest, clavate, its tip obliquely truncate externally, bearing at inner and outer angles a stout spine, which is a little longer than the third joint; third joint shorter than second, cylindrical, with a small tubercle at tip, resembling a fourth joint, and provided at its tip with a fine hair; at the inner side of the third joint, at base of the apical tubercles, arises a stout spine which is almost as long as the joint itself. Piliferous warts, pale brownish, each bearing a long and slender pale hair. Legs rather long, white; only two pairs of abdominal prolegs, situated on joints 8 and 9.

"*Second stage.*—The first molt takes place seven or eight days after hatching; at this time the larvæ differ from the newly-hatched specimens only in the somewhat larger size and slightly darker color.

"*Third stage.*—In from six to seven days the second skin is cast, and with this molt appears the third pair of abdominal legs on joint 7. They are, however, extremely small and scarcely noticeable; they are not used in walking. The color now is a darker green, lighter toward the sides, and with a pair of rather indistinct whitish dorsal stripes. Head highly polished, pale, faintly greenish, with two pale, dusky oblique stripes. Cervical shield slightly dusky, with a darker posterior margin. Piliferous warts black, the hairs colorless. The abdominal legs are marked externally with a broad dusky stripe.

"*Fourth stage.*—The third skin is cast six or seven days after the second molt. The larva is now almost of the color of the leaves, and measures about 14^{mm} in length.

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The ordinary lines appear, the medio-dorsal and the somewhat wavy supra-stigmatal darker than the rest of the body; the subdorsal and tranverse sutures white. The prolegs on abdominal joint 7 are now quite distinct, though rather small, and are used in walking.

"*Fifth stage.*—The fourth skin is cast three to five days later, the larvæ having changed very little in appearance, except that the dorsal and lateral lines and the piliferous warts are distinctly dusky.

"*Sixth stage.*—Five or six days later the fifth skin is shed, and the larva does not change in appearance.

"*Seventh stage.*—The sixth molt takes place about five days after the fifth, and the whole appearance of the insect is considerably changed. The color is pale, translucent, pea-green. The head is not polished, of the color of the body; the two oblique dusky stripes are composed of several irregular spots; the labrum is white, antennæ pale greenish, and the eyes black. The medio-dorsal and subdorsal lines are composed of numerous irregular spots of a lemon-yellow color, the former with a more or less distinct dusky shade on either side; the supra-stigmatal line is quite broad and almost white, and is also relieved by a dusky shade. Piliferous warts pale yellow, surrounded by transversely oval, indistinct, dusky rings. The whole body is speckled with numerous, usually transversely oval, small, lemon-yellow spots, which inclose from two to three almost colorless, glistening, round dots. Stigmata orange. Legs pale green; claws and hooklets pale brown; venter bluish-green.

"Length of full-grown larva about 35^{mm} (1$\frac{3}{8}$ inches).

"*Pupa.*—(Plate II, Fig. 2.)—Length, 15^{mm}. Color, blackish-brown; wing-sheaths opaque, the remaining portion faintly polished. Front of head prolonged into a short, stout, conical projection; near its base ventrally are two fine and quite long hairs and two similar pairs dorsally near insertion of antennæ. Eyes prominent and considerably polished. Legs reaching to tip of wing-cases; antennæ shorter. Median line of prothorax quite sharp and carinate, median line of mesothorax faintly elevated, somewhat polished. The whole anterior portion of body finely and closely granulated. Metathorax and the three following abdominal joints, with numerous shallow, circular depressions, each having a central granule. The circular depressions on abdominal joints 4–8 are somewhat larger and their margin is slightly elevated; the posterior third of joints 4–6 is of a lighter color than the rest of the body and very closely and quite coarsely granulated, while the posterior third of abdominal joints 7 and 8 is polished and not granulated. The last joint is very peculiarly formed; its tip is broad and prolonged each side into a short, stout, and sharp tooth directed forward, and between these two is a pair of slender and also bristle-like spines, directed forward and with their tips curved in the shape of a loop; another pair of similar bristle-like spines, which are directed forward and inward, are situated, one at each side, on a small projection at the base ventrally of the stout lateral teeth, and between these is a large projection which is armed at its edge with two large, stout, claw-like teeth, which stand at right angles to the body of the pupa. The anal swelling is smooth, circular, and quite prominent; the remaining portions of the tip are marked with coarse, elevated ridges, both dorsally and ventrally."

The opinion expressed above that this is exclusively a Southern species is to be modified somewhat by the finding of the eggs and larvæ quite abundantly in September, 1882, on *Abutilon avicennæ* at several localities in the District of Columbia. On September 21, the largest larva was nearly an inch long, and on October 3 it spun up and transformed to pupa. The first moth issued October 15, and on October 16 several moths were captured at sugar. On October 22, quite a large number of larvæ of all sizes, from those just hatched, to the nearly full-grown individuals, were found feeding on the same plant at Ivy City, D. C., and October 25, eggs and young larvæ were found on the

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leaves of *Malva rotundifolia* at Giesborough Point, D. C. The moths from these larvæ began issuing December 1, and more than a dozen had made their appearance by Dec. 4.

ANOMIS TEXANA n, sp.

[Plate II, Figs. 4, 5, 6.]

Another species of the genus Anomis, determined by Mr. A. R. Grote as *A. exacta* Hübn. (and so marked on our plate II), but which is really quite distinct from that species [58], occurs in parts of the South. *A. exacta* is one of the so-called West Indian forms of the genus, and appears in the British Museum Catalogue from Santo Domingo, Venezuela, and Para, but does not occur, so far as we know, in the United States. The species under consideration hitherto confounded with it, occurs in Texas and we have described it as *Anomis texana*. In the summer and fall of 1878, a number of pupæ and one larva were collected by Judge William J. Jones, then one of our field agents, at Virginia Point, near Galveston, Tex. Most of these were reared to the adult state. The larvæ and pupæ are strikingly like those of Aletia, but careful observation will enable one to distinguish them. The moth can be distinguished at a glance.

The full grown larva (Plate II, Fig. 4) seems precisely like Aletia structurally even to the minutest dots on the head and the position of the piliferous spots; but in reality it differs in lacking the first pair of prolegs, which are not only atrophied but entirely aborted. It is distinguished by the more confused and mottled coloration; the medio-dorsal line is more broken and is illy defined; the dorsum proper is more variegated with olivaceous; the subdorsal and supra-stigmatal lines are also less distinctly defined and are narrower and more broken. The stigmatal region is more mottled with pale and dark olivaceous, verging upon ferruginous, and the piliferous spots are not relieved by the same bold white annulus; the stigmata have a narrower black border, and the black spots of head and anal shield are smaller, while the reticulate veining of the head is of a deeper brown. The front pair of abdominal legs, as just stated, is aborted, with no trace of hooklets.

In structural characters the pupa (Plate II, Fig. 5) seems identical with Aletia. It may be distinguished by the fact that it is somewhat smaller, darker in color, not so glossy as Aletia, and is somewhat more coarsely granulated.

The moth (Plate II, Figs. 6, 6*a*) is well represented on the plate and will require no extended description.

LEUCANIA UNIPUNCTA Haworth.

[Plate V.]

This insect, well known in this country in its larva state as the "Northern Army Worm," has, first and last, occasioned a great deal of discussion and even controversy in agricultural reports and journals

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for the last twenty-five years. The most recent as well as the most complete account of the species forms our Chapter VI of the Third Report of the Commission, and in this connection it is unnecessary to repeat the details there given. The reader is, rather, referred to Plate V, where the general appearance of the insect in its different states is well illustrated.

The species is one of very wide range. It is found in its greatest abundance in temperate North America, but is also common in northern South America, India, Java, Australia, New Zealand, and has been captured on the island of Madeira, on the Isle of Wight, and at Lewes, South England. It is found throughout the United States, but is injuriously abundant at intervals principally in the more northern and eastern portions.

The eggs (Plate V, Fig. 1) are secreted at the bases of cereal plants, in the folds of grass blades, and in the sheaths surrounding the stalks. They are usually laid in strings of from fifteen to twenty, and each female moth may deposit as many as seven hundred or more. The eggs are laid more abundantly, and the larvæ consequently appear more abundantly, in the vicinity of old fodder-stacks or in spots where the grass grows ranker or in tufts. The worms (Plate V, Figs. 2, 3, 4, 5) normally feed in a more or less concealed manner on the grasses or grains, and in seasons of exceptional dryness sometimes appear in enormous numbers and march from one field to another in immense armies. They pupate under ground (Plate V, Fig. 7).

There are three broods annually in northern Illinois, and possibly or exceptionally four, and this same number will probably hold for all points between the Ohio River and the great lakes, and north to central New York. Further south the number increases, and in winters of exceptional mildness the development of the insect is not checked for any length of time, and its growth is only somewhat retarded. Thus at Washington, in the calendar year 1882, there were five generations.

The insect hibernates at the North normally in the condition of a half-grown larva, and at the South normally in that condition and as a moth. It is in this latter state that it has frequently been captured and sent to us as Aletia, the general coloration adding much to the resemblance.

Aspila virescens (Fabr.).*

[Plate LXII, Fig. 4.]

This species is not uncommon throughout the Southern States, and has been mistaken for Aletia only in its pupa state, and it is in this condition alone that any resemblance between the two species is observ-

* This is quoted from the West Indies, but we believe it to be the same as that which in our Lists is given as *Chloridea rhexiæ*, and which J. B. Smith, in his Revision of the Heliothinæ (Trans. Am. Ent. Soc., x, p. 220), places in Heliothis. From notes made at the British Museum and from a series of specimens, including three from Brazil and Texas, we conclude that *rhexiæ* is synonymous with *virescens*, the variation between them not being specific [16].

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able. We have already mentioned (p. 17) an instance in which the plowing up of a number of the pupæ of this species was considered absolute evidence of the underground hibernation of Aletia, and indeed to separate the two species in this state requires a trained eye. In general appearance the pupa of *rhexia* is lighter in color and has a blunter anal extremity than that of Aletia. The chief distinguishing character can be readily seen with a hand lens, and consists of two long, slender thorns projecting from the anal end of the body and converging until their points meet.

The larva feeds upon Solanaceous plants, and we have bred it from *Solanum seiglinge* and *Physalis viscosa* at Saint Louis, where the former plant is very rare. A description of the larva is given in Note 16. The moth is smaller than Aletia, and has olivaceous front wings crossed by three light bands, each relieved by a dark greenish shade on its outer order; the hind wings are silvery white, slightly tipped with dusky.

Drasteria erechtea (Cramer).

[Plate LXII, Fig. 5.]

This common moth is indigenous to North America. It is found from Hudson's Bay to the Gulf of Mexico, and west to California. In the British Museum Catalogue it is stated that the Hudson's Bay specimens are hardly more than half the size of those from New York, and Mr. Grote (*Canadian Entomologist*, VII, p. 48) states that while the California specimens agree with the typical form from the East, they are larger. There is also a seasonal difference in size, and we already remarked in 1869 (*American Entomologist*, I, p. 206), "We have observed that the spring brood of this insect are always several sizes smaller than the autumnal brood, and at one time we supposed the two forms to belong to distinct species." We have since abundantly verified the fact of the generally smaller size of the vernal as compared with the autumnal forms, and it has been recognized also by others (see Packard, *Papilio*, II, pp. 147–148). Eggs obtained by us from a large female, October 14, 1881, hatched October 31, and the moths issued from January 9 to April 30, 1882, all being of the smaller size. The colorational variation occurs in all broods and is so great as to have given rise to some eight different synonyms.

While the larvæ of this moth have never occurred in what may be called injurious numbers, yet feeding as they do on grass and clover, they occasion a constant drain upon forage crops. In one instance they have been sent to us as feeding on Cottonwood (*Colman's Rural World*, January 26, 1876). The adult is familiar to almost everyone who has traversed a meadow as the little darting moth which often flies up before one, dropping a few yards away and concealing itself at the base of some clump of grass. In the Northern States there are two annual generations, and the insect hibernates as a pupa. In the middle lati-

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tudes, as at Washington, and Saint Louis, there are three generations, the species hibernating both as larva and imago, while in the South the moths are abundantly found during the winter months, and are frequently mistaken for Aletia. The species will be readily recognized from the accompanying figures (Plate LXII, Fig. 5*e*,*f*), which show, also, the variation which we have obtained from the same batch of larvæ.

We first reared this species from the larva in 1872, and have frequently obtained eggs laid in confinement by captured females. They are deposited on grass leaves and upon the surface of the ground in the breeding cages, as well as upon the muslin covering the smaller breeding jars. One female was observed to deposit 112 eggs. The newly hatched larvæ are pale greenish-yellow in color and are very active, moving with a looping gait. The full-grown larvæ are grayish-yellow, marked with two broad, blackish, somewhat interrupted dorsal stripes. They are described by William Saunders in the *Canadian Entomologist* for June, 1875. Of the eggs and pupæ, which have not previously been carefully described, we submit descriptions in the notes.*[59]

LAPHYGMA FRUGIPERDA (Abbot and Smith).

[Plate LXII, Fig. 2.]

The larva of this insect is commonly known throughout the South as the "Grass Worm," and although usually noticed in moderate numbers eating out the wild grass between cotton rows and elsewhere, and so doing good rather than harm, still there occur at irregular intervals seasons in which it appears in enormous numbers, eats out the grass, "rags" the cotton, eats the corn leaves, and utterly destroys the crops of the vegetable gardens over more or less extended parts of the country. These destructive appearances usually occur late in the summer or in the fall, and for this reason in our Third Missouri Report we gave it the title of the "Fall Army Worm," describing it under the scientific name of *Prodenia autumnalis*, with two of its more marked varieties, *obscura* (Plate LXII; Fig. 2*c*) and *fulvosa* (Plate LXII; Fig. 2*b*). The larva is figured in the Missouri report just alluded to and in our annual report as U. S. Entomologist for 1881–'82 (Plate VII; Fig. 4).

Although the great majority of planters distinguish between the "Grass Worm" and the "Cotton Worm," yet it is owing to a mistaking of the former for the latter that many accounts of a diversity of food-habit on the part of Aletia have been published. The two insects are quite dissimilar in appearance, and in habit still more so. The Grass Worm transforms to a naked pupa beneath the surface of the ground, and hibernates in this condition.

* Since this was written, Prof. G. H. French has published (*Papilio*, Vol. IV, Nos. 7 and 8, September–October, 1884, p. 148) lengthy descriptions of all of the preparatory states of this species.

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PLATYHYPENA SCABRA (Fabr.).

[Plate LXII, Fig. 1.]

This moth is common in almost every portion of the United States, and throughout the South it flies during the winter on all warm, sunny days. Hence, although quite dissimilar to Aletia, it has been frequently mistaken for this moth, and sent to us as evidence of the adult hibernation of Aletia. In the larva state we have found it feeding upon clover and grass at Saint Louis, transforming to pupa within two or three leaves loosely webbed together. At Washington we have also reared it from Solidago. There are two or three annual generations in the latitude of Washington, and more in the Cotton States.

The larva and pupa were described by Professor Comstock, in the Annual Report of the Department of Agriculture for 1879, p. 252, the larva only colorationally; while the larva was, again, very imperfectly described by Mr. D. W. Coquillett, in the *Canadian Entomologist*, Vol. XII, p. 43 (1880). The larva lacks the first pair of prolegs, and in general appearance looks much like a green, immaculate specimen of the Cotton Worm, like which it also acts. We have bred from this larva at Washington the Chalcid parasite *Euplectrus platyhypenæ* Howard.*

PHOBERIA ATOMARIS (Hübner).

[Plate LXII, Fig. 3.]

This is a very common moth throughout the Southern States. It was figured and described by Hübner in his Zuträge zur Sammlung exotischer Schmettlinge, and is mentioned by Guenée as figured in an unpublished drawing by Abbot. We are unable to learn, however, that the early states have been published. This moth has been frequently sent to us from the South during the winter by observers who mistook it for Aletia, and was captured by Judge J. F. Bailey at Marion, Ala., February 16, 1880, while feeding on the nectar from the blossoms of the Mock Orange (*Cerasus carolinensis*).* (See note 19.)

* *American Entomologist*, III, p. 77, March, 1880.

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CHAPTER XVI.

THE BOLL WORM.

(*Heliothis armigera* Hübner).

Order LEPIDOPTERA; family NOCTUIDÆ.

[Plates III and IV].

INTRODUCTORY.

The Boll Worm may very appropriately be classed as among the foremost of the first-class injurious insects. The amount of damage which it does in the course of a year to one crop or another is very great. In many parts of the South it is the chief enemy known to cotton; while there can be little doubt that the corn crop suffers more from its attacks, year in and year out, than from any other one enemy, the chinch bug not excepted. With tomatoes, peas, and beans, though the general injury is not great, yet occasionally the crops of certain sections suffer very severely. The annual drain upon the resources of the country from this one insect may be illustrated by a few quotations from Southern newspapers and from the correspondence of the Department.

Judge Johnson, of Holly Springs, Miss., says in his report: "Of all the injuries to cotton in this latitude none can compare with the Boll Worm, for it is universal and a regular annual visitor.

"This worm is far more injurious in this part of Mississippi than the Cotton Army-worm or any other insect pest."—[Prof. R. W. Jones, Oxford, Miss.

"From all directions come discouraging reports of the cotton crop. The Boll Worm has done its work of devastation so thoroughly that there is now no hope of a greater yield than one bale to eight acres, and in some few cases proprietors will not put pickers to work or give their crops further attention."—[Statistical Report from Grayson County, Texas, 1880.

"Examination into cotton fields in different portions of this county satisfy cotton men and farmers that the damage of the Boll Worm will reduce the yield of the fields examined fully four-fifths. They are reported as ravaging the plant in Denton, and at work on crops raised on

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new land in Tarrant, Johnson, Ellis, Kaufman, Hunt, Rockwall, Cooke, Montague, Clay and Wise counties."—[Texas paper (title not kept), 1880.

"The Boll Worm has already made its appearance in this part of the country, and reliable farmers say that their crops have already been damaged at least 75 per cent., and unless some favorable change takes place they will lose their entire crop."—[Statistical Report, Kaufman County, Texas, 1880.

"Twenty days ago the cotton crop of Ellis county promised an average yield of a bale to the acre; at this time its evident average yield will not exceed one-third of a bale to the acre, the cause of the falling off being the Boll Worm. Some fields of cotton are comparatively little injured, while others are literally destroyed."—[*Galveston News*, September 2, 1880.

"Two hundred and fifty acres of cotton waist high and heavily limbed, was sold to-day for $250 cash. Cause, ravaged by the Boll Worm."—[*Galveston News*, August 26, 1880.

The following extracts are from the answers to the circular sent out in 1878:

"The Boll Worm has, I doubt not, destroyed more cotton in Alabama than the Aletia argillacea."—[D. Lee, Lowndes County, Alabama.

"I would mention the Boll Worm, which bores into the boll and destroys each lobe pierced, and many think the Boll Worm is more destructive on the average than the caterpillar, for the reason that it attacks the cotton more or less every year. I have counted frequently on some stalks as many as 25 bolls destroyed by the Boll Worm. In 1847 there was no caterpillar; but the Boll Worm, from written memoranda furnished me by the Hon. A. C. Mitchell, of Glenville, Ala., very nearly destroyed the crops, being equally as destructive as the caterpillar the preceding year."—[H. Hawkins, Barbour County, Alabama.

"There is a small worm which usually comes in advance of the regular caterpillar, that bores into the forms before the bloom comes out, and it has been my opinion that the damage caused by these is as heavy as any caused by the caterpillar."—[H. C. Brown, Wilcox County, Alabama.

"I believe the Boll Worm has done a great deal more damage in the aggregate than the Cotton Worm."—[C. C. Howard, Autauga County, Alabama.

"The Boll Worm does us more damage upon the whole than the Cotton Worm."—[A. J. Cheves, Macon County, Georgia.

"The Boll Worm (Heliothis) has done more damage this year than the Noctua xylina. They appeared early in June and the third crop is still at work. The crop of this county is cut off at least one-third. A field of sixty acres planted by my brother-in-law, that with no casualties would have made forty-five bales, will barely make fifteen."—[W. Barnes, Cherokee County, Texas.

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"The Boll Worm has done more injury to the cotton plant than any other insect this year. * * * It is said by some farmers that 50 per cent. of the crop is lost on account of the Boll Worm."—[J. M. Glasco, Upshur County, Texas.

"There is one other insect that has destroyed more cotton in this locality in the last four years than all other insects combined. It is known here as the Boll Worm. * * * Its numbers are increasing so rapidly and its destruction so great that it is becoming a terror to the cotton-planter in this locality."—[J. W. Jackson, Titus County, Texas.

The following refer to the damage done to corn by this Heliothis:

"The corn which escaped destruction by the drought was consumed by these worms, so that one county which raised, in 1859, 436,000 bushels of corn, has not this year even 5,000 bushels of wormy corn—and this is a sample of most of the counties in Kansas."—[*Prairie Farmer*, 1861, p. 31.

"All the early corn in this county was infested to a remarkable degree. * * * In the fields examined by myself, which were planted at short intervals from the 15th of March to the 15th of April, and were in roasting ear from the latter part of June, not more than three per cent. of the ears were found without at least one worm."—[Judge L. C. Johnson, Holly Springs, Miss.

"In one field of late corn I found nearly every ear eaten by them, there being from one to half a dozen worms in each ear. In many of them, when my observations were made, while the corn was yet soft, the process of molding and decay had progressed to such an extent that it was difficult to conceive that such corn could ever become anything fit for man or beast to eat."—[G. H. French, Normal, Ill.

During the past three seasons (1881, 1882, and 1883) the damage to corn has been especially marked all through the South and West. It has been a common sight to meet with fields in Virginia and southward in which almost every ear was pierced, while letters from Illinois and other Western States complained bitterly of the damage done.

NOMENCLATURE.

The moth of the Boll Worm, according to the simplest classification of the Heterocera, belongs to the same family—Noctuidæ—as does the Cotton Worm moth, and to the subfamily Heliothinæ. According to the classification adopted by Guenée and followed in the catalogues of the British Museum, however, Heliothis is placed in the family Heliothidæ, tribe Genuinæ, division Trifidæ of the Noctuelitæ, while Anomis is very differently placed in the family Gonopteridæ, tribe Variegatæ, division Quadrifidæ of the Noctuelitæ. The genus Heliothis was founded by Ochsenheimer in his *Schmetterlinge von Europa* in 1816, while the species had been described by Hübner in his *Sammlung europäischer Schmetterlinge*, 1796.

Two synonyms of this species have been published in this country.

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In the *American Cotton Planter* for July, 1850, Mr. J. W. Boddie drew up a short scientific description of the species under the name of *Phalaena zea* [60].

In 1862, Mr. A. R. Grote (Proc. Ent. Soc. Phila., Vol. I), having captured a male of *H. armigera* on Long Island, which differed considerably from the ordinary type, published a description of it under the name of *H. umbrosus*, and remarked concerning it:

> Approaches to the European *H. armigera*, which species has, however, a discal mark on the posterior wings, and is otherwise specifically distinct. It appears also from the description of *H. exprimans* Walker, C. B. M. Noct., p. 687, to have some resemblance with that species, but the expressions "(alæ anticæ) orbiculari et reniformi magnis ferrugineo marginatis," and "(alæ posticæ) litura discali," do not apply to the species I have just described [61].

In the very next year, however, Mr. Grote withdrew the name altogether, having become satisfied of the identity of his type with the common European form.

Heliothis armigera has many popular names. In the cotton fields of the South it is universally known as the "Boll Worm"; in the Southern corn-fields it is called early in the summer the "Bud Worm"; later, the "Tassel Worm", and later still, the "Ear Worm." In the corn fields of the West it is called the "Corn Worm." Tomato growers give it the name of the "Tomato Fruit-worm," or "Corn Worm," and according as it appears on peas, beans, or other vegetables, it receives still other titles.

GEOGRAPHICAL DISTRIBUTION.

It would be difficult to find a more widely spread species than *Heliothis armigera*. It has been found in every quarter of the globe, and, within certain latitudinal limits, its localities of occurrence form a complete girdle around the world. The following list of localities has been gathered from different sources, principally from the British Museum Catalogue of Lepidoptera, and will doubtless be greatly added to as other localities are explored by entomologists.

United States.—All the States as far west as parallel 106 W., and as far north as 44 N. It is also found in California, as we learn from the *Pacific Rural Press* of September, 1879, and two specimens have been received at the Department from Oregon.

Mexico.

West Indies.—Jamaica, Barbadoes, Cuba (Havana).

South America.—Venezuela, Brazil.

Europe.—England, Isle of Wight, France, Spain (Gibraltar), Italy, Germany.

Africa.—Azores, Congo River, Cape of Good Hope, South Africa (coast and interior), Port Natal, Madagascar.

Asia.—Bengal, North India, Mauritius, Ceylon.

Malay Archipelago.—Java.

Australia.—New South Wales, South Australia, Queensland.

Southern Pacific.—New Zealand, Navigator Isles.

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FOOD-PLANTS, OTHER THAN COTTON.*

CORN.—It has for some time been supposed that the first occasion on which attention was publicly called to the fact of the identity of the Boll Worm and the Corn Worm was in Mr. Glover's report upon cotton insects, published in the Patent Office Agricultural Report for 1854, where he gives the credit to Col. B. A. Sorsby, of Columbus, Miss., in the following words:

> There is a striking similarity between the Boll Worm and the Corn Worm in appearance, food, and habits, both in the caterpillar and perfect state, which leads to the supposition that the Boll Worm may be the young of the Corn Worm moth, and the eggs deposited on the young bolls as the nearest substitute for green corn, and placed on them only when the corn has become too old and hard for their food. Col. B. A. Sorsby, of Columbus, Miss., has bred both insects and declares them to be the same; and, moreover, when, according to his advice, the corn was carefully wormed on two or three plantations the Boll Worms did not make their appearance that season on the cotton, notwithstanding on neighboring plantations they commit great ravages.

It is desirable that so important a discovery as this should be rightly credited, and it was therefore with considerable interest that we read the following paragraph in the article on the Boll Worm in the *American Cotton Planter* for July, 1850, by Mr. J. W. Boddie, of Jackson, Miss., from which we have already quoted:

> This insect is an anomaly in the natural history of insects, for it is much more destructive to the plant, cotton (*Gossypium*), for which it was never made, than to the one to which it naturally belongs, corn (*Zea mays*).
>
> If I am right in my supposition, this insect is the caterpillar we find in the end of ears of corn, eating the silk and some little of the corn. This insect is at the North as well as at the South—in fact it is wherever the corn grows and will never depredate on the cotton plant save through necessity.

The same fact of the identity of the two insects was subsequently independently proven and published by Dr. J. H. Zimmerman in the *American Cotton Planter* for 1855, Mr. E. Sanderson, in the same journal, for 1858, and by the writer, in 1864, in the *Prairie Farmer Annual*. The first time Mr. Glover expressed his belief in this identity was also in 1864, the previous demonstrators all having been Southern planters.

Sufficient has already been said in the introduction concerning the destructiveness of the Boll Worm to corn, and there remains to discuss here only its methods of work. In the North there are normally two broods which feed upon corn, and exceptionally three. The first brood occasionally makes its appearance early enough to feed upon the staminate flowers, or "tassels," before the ears are formed. Instances of this are recorded by Mrs. Mary Treat, of Vineland, N. J., who writes to the *American Entomologist*, August 25, 1869, as follows:

> The other day I passed a large field of corn where the depredations of this worm were visible upon almost every stalk. They had done their work weeks before, eating through the leaves while they were folded around the staminate flowers before the ears had begun to make their appearance.

* This section has been published as advance matter from this work in our annual report as entomologist of the Department of Agriculture for 1881–'82, pp. 145–149.

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It is probably the second brood which attracts the most attention and does the most damage. In August and September the infested fields begin to present a sorry sight. Many of the husks are seen to be pierced by circular holes, and, upon opening, the grain is found to be eaten in furrows, principally at the outer end of the ear. If the work has been done before the kernel has set or hardened, the milky juice will have exuded and smeared the end of the ear, when mold soon forms upon it, other insects work their way in and feed upon it, and the whole ear soon presents a disgusting appearance.

Rarely more than one full-grown worm is found in the ear at the same time, though frequently several of different sizes are to be seen. In the course of its growth the worm by no means confines itself to a single ear. As the whim seizes it, or as the flavor of one ear palls upon its appetite, another is entered, either upon the same or an adjoining stalk. The journey from one to another is made in the night, and the new ear is usually entered by a circular hole bored through some part of the husk; so that the mere presence of a hole in the husk does not, as is thought by many, necessarily imply that the worm has left the ear to transform.

From the first to the last of September the worms of this second brood bore out through the husks and enter the ground to transform, those pupating first frequently, in warm seasons in the more northern localities, and always, we believe, in the latitude of South Illinois, Missouri, and Virginia, giving rise to a third brood, which feeds upon the hardened corn if more congenial food is not at hand.

It was formerly thought that the efforts of the worm on corn were confined to the tender and milky ears. In fact we stated (*American Entomologist*, I, 1869, p. 212) that—

> The worm cannot live on hard corn, and it is usually full-grown when the kernels are in the "milk" state.

In 1870, however, we corrected this idea in the following words (see Third Missouri Entomological Report, 1870, p. 104):

> I was formerly of the opinion that this worm could not live on hard corn, and it certainly does generally disappear before the corn fully ripens, but last fall Mr. James Harkness, of Saint Louis, brought me, as late as the latter part of October, from a corn-field on the Illinois bottom, a number of large and well-ripened ears, each containing from one to five worms of different sizes, subsisting and flourishing upon the hard kernels.

Prof. E. W. Claypole, of Antioch College, Yellow Springs, Ohio, also called attention to the same fact in the November (1880) number of the *American Entomologist*. He says:

> In cutting my own corn yesterday I found many specimens of this insect, and there now lies before me an ear almost uninjured and nearly dry, the kernels being too hard to yield to the nail, and full of meal when broken, in which is an almost full-grown worm engaged in eating these hard grains. * * * Later. I have as late as the first week of this month (October) found small Corn Worms, not more than half an inch long, engaged in eating the ripe ears of corn, and I can add from experience that these small worms can bite sharply.

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Last fall (1881), in the vicinity of Canton, Ill., Professor Barnard observed that much damage was done to late corn, over two-thirds of the ears harvested having contained one or more worms. Live worms were found in the ears up to the time of husking, in the latter part of October, feeding upon the hard kernels. The ears thus damaged exhibited on husking many shallow grooves through the tops of the kernels, which seemed, indeed, the favorite mode of work of the worms; but occasionally a single kernel would be eaten down to the cob. There, as elsewhere, mildew had served to greatly increase the damage done by the worm.

In the Southern States there are always three broods of the worm upon corn, the later broods preferring the tender cotton bolls to the tough corn. The moths in early spring lay their eggs on the leaves of the corn, and the newly-hatched larvæ begin feeding at once on the spot of their birth. By these young larvæ many irregular holes are eaten through the tender leaves, giving them, as has been well said, the appearance of having been riddled by a charge of small shot. In this manner they feed for some time, gradually working their way downward into the sheath of the leaf, and finally reaching the closely-rolled terminal bud, into which they bore and remain feeding until they attain their full growth, when they gnaw directly outwards, and, crawling into the ground, transform to pupæ.

The eggs of the second brood are laid upon the leaves and upon the sheaths of the tassels about the 1st of June. The worms feed, as before, upon the leaves at first, upon the tassels, and, later, as they approach full growth, they are to be found feeding upon the kernels, silk, and cob of the forming ears.

The third brood, commencing shortly after the 1st of July, may be compared in its destructiveness to the second brood at the North. It is very numerous, and is the last brood which injures corn to any extent. The eggs are laid upon the end of the husk or amongst the silk, and the worms work in the manner previously described, occasionally piercing the husk and migrating from one ear to another, although the tendency to do this is much less when the ears are tender than after the grains have begun to harden. The worms of this brood pupate in the usual way, and those of the next betake themselves almost exclusively to cotton. Occasionally a worm is found working in the ears of hardened corn in close proximity to a cotton-field, but it is a comparatively rare occurrence.

Much of the history of the Boll Worm upon cotton is inseparably connected with its life upon corn, so that we shall have occasion hereafter to again refer to its relations to the latter crop.

Tomato.—Perhaps next in importance to the damage done to cotton and corn comes that done to the tomato crop. In 1867 the Boll Worm played havoc with the tomatoes of Southern Illinois, eating into the green fruit and causing it to rot. (See *American Entomologist*, I, 212).

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In his report for 1870 Mr. Glover speaks especially of the damage to this crop the previous year in Maryland. The worm bored into both the ripe and unripe fruit of the tomato, rendering it wholly unfit for use. It was said that a single caterpillar would ruin a number of the fruit on one plant alone.

Mr. Crane, of Mandarin, Fla., an extensive vegetable grower, lost, in 1878, one-third of his crop of tomatoes through this Heliothis.

Prof. J. E. Willet, of Macon, Ga., in correspondence with the Department in September, 1879, related the interesting fact that in the vicinity of Macon, at least, the Boll Worm had developed the mischievous habit of boring into the tomato-stalks until they were nearly or quite severed, thus doing more damage than it could have done by confining itself to the fruit. The larvæ have also been found feeding upon the leaves of tomato, at Washington, by Mr. Pergande, one of our assistants.

The Boll Worm has also been found by J. Jenner Weir to feed upon the tomato plant in England, and we have already elsewhere commented upon the interest attaching to this fact, since the tomato is grown with such difficulty in England.*

TOBACCO, AND OTHER SOLANACEÆ.—So far as we know there has been no record of injury to tobacco by the Boll Worm in this country; but Mr. Ch. Goureau, in his *Insectes Nuisibles* (second supplement, 1865, p. 132), mentions the fact that it devours the leaves of this plant where cultivated in Europe.

Of other Solanaceous plants we may mention the red pepper (*Capsicum annuum*), the Jamestown or Jimpson weed (*Datura stramonium*), and the Ground-cherry (*Physalis*). The injury to peppers is mentioned by Professor French in the report of the Illinois State Entomologist for 1877, p. 102, while the observation on Stramonium was made by Dr. Barnard and Mr. Schwarz, at Selma, Ala., in August, 1880. On *Physalis* they were seen by Dr. A. Oemler, at Savannah, Ga., and we found them ruining the fruit of this plant in all parts of Kansas in 1877.

LEGUMINOSÆ.—The Boll Worm is very fond of boring into the pods of Leguminous plants. The pod of the common garden pea (*Pisum sativum*) is frequently destroyed by it.†

Boll Worms were discovered feeding on the common string-bean (*Phaseolus vulgaris*) in the vicinity of Kirkwood, Mo., by Miss Mary Murtfeldt. In October, 1879, specimens were received from D. Landreth & Sons, Philadelphia, which had damaged their Lima-beans to the extent of from 3 to 5 per cent. Upon the field bean they were observed feeding by Mr. Howard, near Savannah, in 1881. With all these species of beans, and with the garden pea, the method of work is the same—the worm

American Entomologist, II, p. 172.

†See quotation from Mrs. Mary Treat, in the *American Entomologist*, Vol. II, p. 42. See also Glover's report of the Entomologist for 1870, p. 84; our third Missouri Report, p. 105; and report of Prof. William Trelease, in the Report on Cotton Insects, 1879.

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bores into the pod at some one point, and never leaves until the entire contents are ruined. With the common Cow-peas of the South (*Vigna* and *Dolichos*, spp.), in the pods of which Heliothis is very often found feeding, the work is frequently done in quite a different way. The seeds are separated by marked fleshy partitions, and, rather than pierce these partitions, the worm bores through to the outside and enters again opposite to another pea. In the same manner it infests *Erythrina herbacea*—a leguminous plant which grows wild through the South, more commonly near the coast. (See Report on Cotton Insects, Department of Agriculture, 1879, p. 296.) In Europe it is found on Lucerne (*Medicago sativa*) according to Goureau (*ibid.*), and upon the Chick-pea (*Cicer arietinum*) according to M. J. Fallou (*Insectologie Agricole*, 1869, p. 205). In the latter case the young worms feed upon the leaves and the older ones bore into the pod.

CUCURBITACEÆ.—Among the Cucurbitaceæ several useful plants are injured by the Boll Worm. Glover, in 1870, records pumpkins (*Cucurbita pepo*), and Judge Johnson, in his report to us, mentions melons (*Cucumis melo*) and summer squash (*Cucurbita verrucosa*). Mr. Glover, as long ago as 1855, found the Boll Worm feeding in the flowers of squash. (Glover, Patent Office Agricultural Report for 1855, p. 100.)

MALVACEÆ.—Professor French (Seventh Report of the State Entomologist of Illinois) reports the worm as feeding on the growing seed-pods of the large-flowered Rose Mallow (*Hibiscus grandiflora*) along streams in Illinois. He has recently published the fact, however, that the larva concerned in this injury was not Heliothis, but a Pyralid.*

The useful Okra or Gumbo plant (*Hibiscus esculentus*) is often destroyed, according to Judge Johnson, by this larva.

OTHER FOOD-PLANTS.—The families Iridaceæ, Convolvulaceæ, Urticaceæ, Resedaceæ, Geraniaceæ each contain a single food-plant of Heliothis. Mrs. Treat, in her Vineland address on insects, quoted from in the *American Entomologist*, I, p. 43, mentioned the Gladiolus, grown frequently in flower gardens, as being occasionally eaten in the spring by the Boll Worm. Mr. Schwarz several times found the worm, at Selma, Ala., feeding on the green fruit of *Ipomoea commutata*. He remarks: "It is a very curious sight to see this large larva with its head imbedded in the comparatively small fruit of this plant." Mr. Goureau (*l. c.*) mentions hemp (*Cannabis*) as one of the European food-plants, and Kaltenbach (Pflanzenfeinde, &c., p. 42) states that the worm lives from June to August on the Dyer's Mignonette (*Reseda luteola*).

Within the last year the worms were received from Mr. Daniel Wilter, of Denver, Colo., as boring into the stems of his garden Geraniums, and also eating the leaves of the same plant.

These are, so far as we have been able to ascertain, all of the food-plants of *Heliothis armigera* yet known or at least yet recorded. Others will undoubtedly be found from time to time, and it is not improbable that the present list could be swelled into the hundreds by a diligent and

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specific study of this insect for a year or two, for enough has been said to show that it is a very general feeder.

In this connection we cannot avoid making the statement that the Boll Worm is by no means exclusively vegetarian in its diet, although this point will be fully discussed in the special report. It has been repeatedly known to devour the pupæ of the Cotton Worm (*Aletia xylina*) when free upon the plants, and has moreover gained a wide reputation as a cannibal, the larger individuals frequently dining upon the smaller ones.

CHARACTERS AND TRANSFORMATIONS.

THE EGG (Plate III, Fig. 1; Plate IV, Fig. 1).—The egg of Heliothis is 7^{mm} in diameter, its axis being about equal to its greatest diameter, which is near the base. In color it is nearly white, rather inclined to yellowish, and is easily detected against the green background of leaf, stem, or involucre. Upon certain of the eggs shortly after being laid there appears a reddish-brown band near the summit, which disappears with the growth of the embryo. The worm itself can be seen through the semi-transparent shell as it approaches the hatching point. The sculpture of the egg—the polar ribs with their cross-furrows—is almost identical with that of Aletia.

The only published statement we have ever seen as to the number of eggs laid by a single moth was by Glover, who, in 1866, stated that a correspondent had dissected a female moth and found it to contain more than 500 eggs.

Mr. Glover, misled by some cause or other, makes the following statement concerning the place of deposit of the eggs:

> The egg is generally deposited singly on the outside of the involucel or outer calyx of the flower or young boll, where it adheres by means of a gummy substance which surrounds the egg when first laid, and which hardens by exposure to the atmosphere. It has been repeatedly stated by planters that the egg was deposited on the stem, and that the young stem forms the first food of the newly-hatched caterpillar; but after a careful examination of several hundred stems I found only one egg placed in this situation, and that from the fact of its being laid on its side instead of the base, had evidently been misplaced.

The truth of the matter is that the eggs are to be found on all parts of the plant, more, perhaps, being deposited on the under side of the leaf than elsewhere. A few can be found on the stalks, and many on the upper surface of the leaves, and quite a large proportion also upon the involucre. Occasionally, too, an egg is to be found on the stem of the boll or upon a leaf petiole. During the hot weather of July and August by far the greatest number will be found on the under side of the largest, darkest leaves. The favorite time for oviposition is at or just after twilight, when the moths can be seen flying in great numbers.

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*This statement was contained in a report prepared by Professor French, for the Third Report of the United States Entomological Commission, but which has been independently printed in the Eleventh Report of the State Entomologist of Illinois.

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The duration of the egg state is said by Prof. R. W. Jones to be from three to five days, but in spring and late fall a longer time elapses before hatching, while in midsummer the worms may occasionally appear in two days from the time of oviposition.

THE LARVA (Plate III, Figs. 2, 3, 4, 5; Plate IV, Figs. 3, 6, 10, 13, 14, 15, 16, 17, 18, 19, 20, 22).—The newly-hatched Boll Worm has much the appearance of the young Cotton Worm. It is rather darker in color, however, and though walking like a looper to a certain degree, its pro-legs are much better developed than is the case with Aletia. No marked difference in the size of the legs is observable, except that the anterior pair, although apparently perfectly formed, is shorter and weaker than the others. The head is large, as are also the piliferous tubercles, while the hairs are long and stout in proportion to the size of the body. The larva feeds at first at the spot on which it was born, be it leaf, petiole, stalk, involucre, corolla, or boll; but it soon manifests a migratory tendency, crawling from one leaf to another, and letting itself drop and swing suspended from a line of silk, until, sooner or later, a young bud or boll is found, into which it bores. It often happens that several days pass while the young worm is searching for a boll, during which time it feeds upon the leaves. Indeed, as will be instanced later, the worm may and does occasionally pass the whole of its larval existence with no other food than leaves.

The passage of the young Boll Worm into the flower bud is a frequent—perhaps the most frequent—cause of the flaring of the involucre and the final dropping of the bud or young boll. (Plate IV, Figs. 8, 9.) The idea that this "shedding of cotton," as it is called, is mainly caused by insects, is not generally accepted at the South; yet such is the case, and the Boll Worm is the chief of the malefactors. An examination of the shed bud or boll will show that in nearly every case it is pierced by a small hole. (Plate IV, Fig. 2.) Frequently granular excrement is to be seen on the involucre, between it and the boll, and when this is the case it is proof positive of the agency of Heliothis. But frequently, also, a hole or puncture is to be seen with no sign of excrement. In such cases it is probably the work of some Hemipterous insect. Of these, Mr. Glover has briefly described *Calocoris rapidus* Say, and *C. bimaculatus* H. Schf., in the following words:*

I observed three insects (*C. bimaculatus*) when confined under glass, sucking the sap from the buds and young balls, their only food. The young eventually completed their transformations into perfect insects. They were observed, moreover, to eject large drops of green sap from their abdomens, which could only have been procured from the buds themselves. * * * The perfect insect is seven-twentieths of an inch in length; the antennæ are brown and green, the eyes brown; the thorax somewhat triangular; the anterior part green, and shaded with reddish-brown posteriorly; the legs brown and green; the wing-cases with a cross, shaped like the letter X, forming four triangles, those nearest the thorax being reddish-brown; the side triangles are green.

*See Bibliographical List: Glover (1855).

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There is likewise another species (*C. rapidus*) which was found perforating the young flower buds and bolls of cotton similar to the above. The head and anterior portion of the thorax are reddish-brown, the remainder of the thorax yellow with a double mark in the middle; the wing-cases are brownish-black, with two longitudinal yellow lines from the upper outside corner of the wing-cases to the posterior edge, forming a dividing mark, somewhat shaped like the letter X.

He has also described a species of Lygæus having similar habits (*ibid.*). In his manuscript work on Cotton (see Glover, 1878, Bibl. List) he figures *Leptoglossus phyllopus* (Lin.) (=*Anisoscelis albicinctus* Say), *Euschistus punctipes* Say, and *Nezara pennsylvanica* De Geer, all of which are said to have been found piercing cotton bolls or buds, although their habits are normally predaceous.

The amount of damage done in this way by the Boll Worm is very great, as a single young larva will travel from bud to bud, deserting each before its fall, until many have been destroyed. A bud pierced just before opening is forced into premature bloom; but the worm usually feeds upon the essential reproductive parts, rendering it incapable of fructifying. (Plate IV, Fig. 3.)

As the worms increase in size a great diversity in coloration and also in markings appears. Those individuals which have nearly reached their full growth vary from a dark brown or rose color to a light green, the latter being, perhaps, the predominant shade. Almost every conceivable intermediate stage of color is to be seen, while the markings vary almost as greatly. It seems to be well settled that the green worms are most abundant in the spring, while later, as the cotton blossoms out fully and the silk of corn begins to assume its reddish tinge, the pinkish variety becomes more abundant and the brown worms do not appear in force until fall.

In markings the worms vary from almost perfectly immaculate, unstriped individuals to those furnished with many spots and regular stripes. The commonest (we can hardly say the normal) arrangement of the markings is as follows: On each side of the body, extending from the head to the anal joint and including the spiracles, is a broad, whitish, lateral or stigmatal stripe. Just above this is a less broad subdorsal dusky stripe. Down the middle of the back is a narrower, dusky, mediodorsal stripe, including a fine white line, and between this and the subdorsal dusky stripe, in what may be called the dorsal space, are four or five very delicate whitish lines, so delicate in fact as not to interfere with the general color of the body. Of spots there are usually eight dorsally to each abdominal joint, normally black in color, the four dorsal spots arranged trapezoidally, the anterior pair closest together. These spots are simply piliferous tubercles and are very constant, a close examination of even the immaculate individuals showing them still to be present, though colorless. Upon the meso- and meta-thoracic joints these tubercles are arranged across the dorsum in a single transverse row. Of the stripes the most constant appears to be the whitish lateral, all the others being more often wanting.

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That these color varieties are not caused by a difference in food is shown by the fact that all the variations occur in specimens feeding on one and the same plant. Those feeding on maturing corn are always dark, however, and the colors brighten in proportion as the larvæ are exposed and not hidden in feeding.

As the worms grow they attack larger bolls, the young larvæ having mainly confined themselves to the buds and newly-formed bolls. (Plate IV, Fig. 6.) The worms may, therefore, be said to progress downward, the younger individuals being found mainly upon the top crop, while the older larvæ bore into the older bolls of the middle crop, the bottom crop being seldom seriously damaged by Heliothis. The half-grown worm finding a boll of a suitable age, begins at once to gnaw through the smooth covering, soon forming an opening as large as the diameter of its body, and through this opening it gradually works its way into the interior of the boll. Frequently the spot first tried proves too hard or otherwise distasteful, and the worm leaves it either for another boll or for another spot on the same boll. Infested bolls can usually be distinguished by the opening, but occasionally this is hidden by the involucre. Having devoured or partially devoured the contents of one boll, the worm leaves it for another. Even if, however, the damage to the contents has been slight, rain penetrates through the opening, the boll soon rots and attracts other insects (principally Dipterous and Coleopterous), which finish the work of destruction. In this way an immense amount of damage can be done by a single larva. Prof. R. W. Jones says in his report: "The amount of damage done by a single worm is surprising. I have counted eighteen young bolls shriveling, decaying or fallen, besides many blooms and unopened flower buds pierced; all the work of one Boll Worm, and that not grown."

The disease known as "boll-rot" has recently been laid to the account of the Boll Worm. This disease is said to have made its appearance as early as 1810, and to have prevailed for ten years or more, frequently destroying whole crops. The introduction of the Tennessee green-seeded cotton seemed to stop the spread of the disease. About 1850, however, it is said to have reappeared, and since then has been an occasional source of considerable damage to the crop. The rot manifests itself at first by a slight discoloration, resembling a small spot of grease. Either one or all of the interior divisions soon rots, and the boll frequently bursts and discharges a putrid mass. The disease has been variously attributed to the agency of some fungus growth, to an organic disease of the plant brought on, perhaps, by a superabundant moisture of the soil, and to the attacks of insects. The results of the rot—in the shape of insects attracted by the diseased condition of the boll—have long been considered as among the causes.

Professor Stelle, in one of his reports to us (see Appendix III) believes that the rot can all be laid at the door of the Boll Worm. He claims by his observations to have proven that the greasy-looking

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bruised spot, which is the first manifestation of the rot, is simply the result of the gnawings of the worm in its attempt to penetrate the boll at that point. Bolls thus spotted were, as he reports, watched until in every case the rot supervened.

In spite of the confidence with which Mr. Stelle puts forth this theory, our experience would indicate that he is mistaken. In fact we have learned to question the trustworthiness of his statements. We have repeatedly seen bolls badly gnawed both by Aletia and by the Boll Worm, as well as by other Lepidopterous larvæ, which yet were sound and good inside, and we believe the cases mentioned by Mr. Stelle to have been simply coincidences. We may also adduce the fact that the gnawings of the worms into tomato and Physalis, fruits which rot very easily, seldom if ever produce rot. The only decay actually caused by the Boll Worm to the cotton boll occurs where the seed-cavity has been pierced and rain has been enabled to enter.

Many instances of the carnivorous propensities of the Boll Worm have been met with during the past few years. We have known the larger worms (and the act has been repeatedly seen by observers in the employ of the Commission) to seize upon the smaller worms, biting through the skin and feeding upon the juices of the body. And this has not only been done in the confined breeding-jars, but upon the cotton plant, in open air, with an abundance of vegetable food at hand. Professor Willet, as we learn from his correspondence with us, has also noticed the same occurrence with these worms when feeding upon tomato, and Judge Johnson has noticed the same habit among the corn-feeding worms. More interesting, however, than this, even, is the habit which the Boll Worm has of occasionally preying upon the pupæ of Aletia. This was observed we think for the first time by Mr. Trelease while in the employ of the Department of Agriculture during the summer of 1879, at Selma, Ala. He says:

Owing to its tough integument, the pupa of *Aletia* seems to be freer from insect attack than the larva is, yet even its hard skin does not always save it. About the middle of August I first noticed what appeared to be an anomalous preparation for pupation in the boll-worm (*Heliothis armigera*), for I found several full-grown larvæ of this species with leaves closely webbed around them, precisely as *Aletia* webs up before changing to a pupa. An examination of one of these leaves, however, showed me that the boll-worms had not webbed them about themselves, but had insinuated themselves into leaves folded and preoccupied by *Aletia*, the latter having already passed into the pupa state, and they had done this for the express purpose of feeding on these pupæ. *Many cases of this sort were seen.*

Judge Johnson gives the following very interesting account of this habit in his report of observations:

Though almost omnivorous, Heliothis larvæ are essentially pod borers and seed eaters. They will take to anything having the appearance of a pod. This is curiously manifest in their preference for the chrysalides of other Lepidoptera. The larger worms would leave everything for the pupæ of Aletia when they were plentiful. This special omnivorous appetite was first noticed September 23, in company with Professor Jones, whilst we were experimenting in a field infested with Aletiæ.

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There were hundreds of the pupæ devoured by some enemy that broke into the larger end. Much of this work was freshly done; and when we first observed it, a few days previously, I was disposed to attribute it to a small black or dark-brown grub (supposed to be a Telephorus), many of which I found in the newly-rifled chrysalids, devouring the remains. But these were never in sufficient numbers to account for the destruction of the Aletiæ. Professor Jones on the occasion alluded to caught a boll-worm in the very act; and I have since verified their propensity by finding them to prefer this diet to every other. Further observation, therefore, led me to acquit the little Telephorids of initiating the robbery. They only play the jackal at this feast; the lion they follow is the boll-worm.

Dr. Anderson, in one of his letters, says: "Accompanying this I send a larva (*Heliothis armigera*) found preying upon Aletia larva in its web, and this has been so often repeated as to induce me to think it may be classed among those destructive to Aletia."

This habit was also observed by Mr. Hubbard in Florida and by Mr. Schwarz in Alabama. The latter states that it was more often the strongly marked, highly striped individuals which were found preying upon the Aletia pupæ than any other variety.

No instance, so far as we are aware, have been noticed or recorded where the Boll Worm has been found feeding upon Aletia larvæ when free upon the plant; but in the breeding-cages it will eat almost anything in the shape of a Lepidopterous larva, no matter how much vegetable food may be supplied to it. An interesting instance of this came under our notice in 1882, in the case of a larva of Heliothis found feeding upon tomato leaves, which, when placed in a breeding-cage with larvæ of *Plusia brassicæ*, found upon the same plant, not only destroyed the Plusia larvæ in preference to feeding upon the fresh tomato leaves furnished to it, but even penetrated a newly spun cocoon and devoured a larva which was filled with specimens of *Copidosoma truncatellum*, parasites and all.

The length of life of the larva of Heliothis varies of course with the season of the year, and also with the state of the weather. According to Dr. G. W. Smith-Vaniz, of Canton, Miss., who has reared the worm from the egg state, it occupies from egg to pupa, in the month of August, twenty-one days. Prof. R. W. Jones, without further qualification, places it at from fifteen to twenty days, and Judge W. J. Jones states that the early brood in corn spends three weeks in the larva state. The only detailed statement of the growth of the worm yet published is the following, taken from Glover (1866):

A Boll Worm which was bred from an egg found upon the involucre or "ruffle" of a flower-bud grew to rather more than a twentieth of an inch in length by the third day, when it shed its skin, having eaten in the mean time nothing but the parenchyma or tender fleshy substance from the outside of the calyx. On the fifth day it pierced through the outer calyx and commenced feeding inside. On the sixth day it again shed its skin, and had increased to about the tenth of an inch in length. On the tenth day it again shed its skin, ate the interior of the young flower-bud, and had grown much larger. On the fourteenth day for the fourth time it shed its skin, at-

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tacked and ate into a young boll, and had increased to thirteen-twentieths of an inch in length. From this time it ate nothing but the inside of the boll, and on the twentieth day the skin was again shed and it had grown to the length of an inch and one-tenth, but, unfortunately, died before completing its final change.

There is, however, in this instance something of an abnormal character in addition to the fact that the measurements of the early stages are obviously insufficient. The growth was evidently watched in a breeding-cage, and perhaps at the North.

The full-grown, well-developed worm averages 4^{cm} (1. 57 inches) in length and about 7^{mm} (0. 27 inch) in diameter. On arriving at full growth the worm works its way to the ground, and, choosing a spot where the earth is somewhat compact rather than loose and friable, burrows beneath the surface and forms a subcylindrical, straight or sloping gallery to the depth of from three to six inches. This gallery is slightly closed at its mouth and gradually widens towards its lower end, where the worm transforms to pupa.

THE PUPA (Plate III, Fig. 6).—The old and generally accepted statement was that the pupa of Heliothis is found underground in an oval cell composed of particles of earth held together by a loose, gummy silk. In Illinois, at least, Professor French has found that the winter brood pupates in a somewhat different way. We quote from his article in the *Prairie Farmer* of October 26, 1878:

When the larva attains its growth it descends to the ground, into which it goes to pupate. In doing this it usually selects some place where the earth is rather firm, seeming to prefer the security a compact soil can give, to ease in digging.

It digs a hole into this several inches in depth apparently cementing the dirt as it goes down, so that when it reaches the desired depth there is a smooth channel from the bottom to near the surface, there being a thin film of dirt over the entrance.

This hole, as I found in digging about corn-hills, is about a third of an inch in diameter, larger at the bottom than at the top, apparently so as to give free motion to the chrysalis, and is usually bent in its course so that the lower part would have an inclination of often as much as forty-five degrees. I found the chrysalis at the bottom of this, the small end downward. In one instance I found a hole so bent that the chrysalis occupied a horizontal position. * * * I began digging for the chrysalids in November in a field where the worms had been abundant in the corn, using at first a spade and digging at random. I had expected to find them in oval "cocoons," as they were supposed to make, but cutting across channels in which I afterwards found chrysalids led me to dig a little more carefully. I soon found that by running the spade along the row and and taking off half an inch or less of the surface I could tell where every chrysalis was to be found.

The presence or absence of this smooth coherent tube or "channel," as Professor French calls it, depends greatly, without doubt, upon the friability of the earth in which the burrow is made, as extremely loose earth would fall in upon the worm, obliterating the tube. The "oval cell" is nothing more nor less than the rounded ending of the tube, and it would be a stretch of the imagination to call it an earthen cocoon, yet a thin film of silk is usually to be seen upon the walls.

Deprived of all earth, we have known the Boll Worm to pupate nakedly and in apparently as healthy condition as though the surround-

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ings had been normal. (See, also, report of Judge Lawrence C. Johnson, Rep. Ent., Dept. Ag., 1881–'82, p. 150.) The length of time which Heliothis remains in the pupa state in the cotton fields in midsummer varies from seven to ten days. In spring and in fall the time may lengthen to fifteen, twenty, or even more. Ordinarily the insect goes on propagating till frost, but occasional instances are met with where a pupa will remain quiescent from early in September, and even in August, on through the winter.

The pupa may be described as follows:

Length, 20mm (0.8 inch); color, light mahogany brown, darker toward head. Head covered with small, faint granulations and with a few shallow transverse impressed lines anteriorly; also a few irregular impressions behind the eye; about midway from the posterior angle of the eye and the posterior border of the head is an impressed puncture, from which a short, stiff hair arises; there is also another shallow triangular impression on the medio-dorsal line near the posterior border of the head. The whole dorsal surface of the thoracic joints is finely punctate, and is covered with irregular, shallow, impressed, transverse lines; the metathoracic joint is much wrinkled dorsally. The surface of the abdominal joints is similarly sculptured; the anterior margins of joints 4 to 7 are coarsely punctured; joint 4 has but few punctures, but on 5, 6 and 7 they are numerous; the more anterior of these punctures are deep, and they extend posteriorly into long, shallow, longitudinal impressions; the posterior dorsal margins of each of these joints are covered with dark-brown granulations of differing forms. The other joints, except the last, have nothing peculiar in their structure; the last joint is rounded and furnished at the tip with two long, slender, black spines. Ventrally the last and the penultimate joints have each a deep longitudinal medial impressed line. Wing, leg and antennal cases covered with shallow punctures.

THE IMAGO (Plate III, Figs. 7, 8, 9).—As we have already stated, *Heliothis armigera* is an extremely variable species, as would naturally be expected from its multitudinous food-plants and its almost unlimited distribution.

In general color the moths vary from a dull ocher-yellow to a dull olive-green. The two extremes are well shown upon the plate at figures 7 and 8. In these figures the normal type of markings is also shown, but in this respect, also, there is great variation. Many individuals exhibit almost immaculate front wings, while in others the typical markings are deepened far more than in the figures. In a general experience covering some twenty years with this moth, as found in corn-fields in the West, and covering some half-dozen years in the cotton-fields of the South, we believe that the former are on an average brighter colored and darker than the latter. The markings of the hind wings, although much more constant than those of the fore wings, vary principally in the breadth and depth of color of the dusky band on the hinder margin, and in the size of the light spots within this band. With the figures, and the description already quoted (p. 358) of the form called *umbrosus* no more extended popular characterization of the moth will be necessary.

The position of the moth when at rest is characteristic, or at least distinguishes it radically from Aletia. The latter, it will be remembered,

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holds its wings tightly closed, roof-shaped, over its back, only the fore wings being visible; the former, on the contrary, carries its wings slightly elevated, and also slightly open, so that a portion of the abdomen and of the hind wings can be plainly seen, as is shown at figure 9 of the plate, which, as also the corresponding figures of the Cotton Worm moth, were sketched by us from nature in the field.

In passing through a cotton-field or an adjoining patch of cow-peas during the day any number of Boll Worm moths will be flushed and will fly away with that blind, quick, darting motion common to nearly all Noctuids in the broad light of day. At night-time, however, their flights are longer. Judge Johnson says: "They seem to prefer to hide in the cow-peas and in the clover—when these grow near—and may be seen about sunset sucking the honey secretions of flower-stems of peas, and dipping into the blossoms of clover." Their regular flight begins at sundown, or shortly thereafter, and they feed, in addition to the plants already mentioned, on the nectar of the cotton plant and of the coffee-weed, and also on other nectar-secreting plants.

On one occasion Mr. Schwarz found the moth feeding in the middle of the day upon a blossom of *Helenium tenuifolium*.

In feeding, the behavior of the moths is much like that of Aletia, the antennæ being kept in almost constant vibration. They have also been observed to hover before a gland, steadying themselves with their fore legs. When at rest and sucking nectar, as before stated, they do not fold the wings like Aletia, but keep them raised and partly open. The tip of the maxillæ or haustellum is armed much as in the Cotton Worm moth, save that the point is not so sharp and the penultimate portion is not so strongly barbed. We have heard no authenticated account of damage perpetrated by the Boll Worm moth, but the similar armature of the maxillæ plainly indicates that it is, or has once been, the habit of the moth to pierce the skins of fruit.

NUMBER OF BROODS.

It is impossible to speak with any degree of definiteness concerning the number of annual broods of the Boll Worm in the Southern cotton-fields. A confusion of generations begins very early in the season, and we soon find the worms in the field in all stages. Accidental circumstances may favor the development of the descendants of one moth and retard that of another. Generation after generation is produced until the approach of cold weather, and consequently much depends on the length of the season. The average length of time occupied by the insect in all of its transformations is, say, thirty-eight days, and this, allowing from the 15th of April to the middle of October as the active period of its life, would give us five broods. This is, so far as we can ascertain from actual observation, the normal number throughout the more southern portions of the cotton belt.

As we have already stated under the head of food-plants, the first

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three broods feed usually in corn-fields. The first brood makes its appearance about the 1st of May or a little before, and feeds almost exclusively upon the leaves and terminal buds of corn. The second brood, appearing in early June, feeds upon the tassels and forming ears; and the third brood, which corresponds nearly with the second brood at the North, appears in July and feeds upon the hardening corn, boring through the husks and pupating underground, as its predecessors have done. At the time of the appearance of the next brood, however, the kernels of corn have become hard, and in preference the moths oviposit upon cotton, which at this time bears many bolls of a sufficiently tender age. Previous to this, however, worms will have been found upon cotton which have attained their full growth, with no other food than the leaves and flowers of this plant. These cases are, however, exceptional, although by no means very rare. Other crops on the plantation suffer from these worms during the early part of the season, and in speaking of the early corn-feeding habits we are treating only of the bulk of the brood.

The first time, then, that the Boll Worms are to be seen in force upon cotton is about the first of August, and these worms are usually representatives of the fourth brood. Our observers are unanimous in stating that from this point there are two broods on cotton, the second brood beginning about the second or third week in September and entering the ground to pupate from the first to the middle of October. Occasionally the final transformation for the season may take place considerably earlier. Thus Dr. G. W. Smith-Vaniz has reported a worm which entered the ground September 22 and remained in the pupa state all winter. Normally, in fact, the Boll Worms disappear some time before the Cotton Worms do. Here, again, in treating of the last two broods upon cotton we speak only of the bulk of the brood, for some few larvæ are always to be found feeding upon the hard kernels of corn until late in the Fall.

If, as we have stated, there are three normal broods a year as far north as New Jersey, Ohio, and Northern Illinois, then in South Carolina, North Georgia, Tennessee, and Arkansas there are probably four broods, and as many as six in South Texas and Florida.

HIBERNATION.

There can be no doubt whatsoever that the normal method of hibernation is in the pupa state. We have already described the pupa cell, and given the dates for the disappearance in the fall and the appearance of the moths in the spring; so little more need be said under this head. Concerning the moths which, induced by a warm autumn, issue too late to find food for their progeny, we are at a loss to say what becomes of them. Judging from analogy, it would seem as if there were nothing to prevent them from hibernating; yet the fact remains that among the enormous number of moths either captured by us or our assistants, or sent to us by correspondents, during the past four years, as hibernating

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Aletias, there has not been a single Heliothis. In a warm fall the moths have been known to issue during the month of November; but whether these individuals die or exceptionally hibernate is as yet an undecided point. Our former statement (Third Missouri Entomological Report, p. 107*) as to the hibernation of moths was made after observations during a late fall, when most of our specimens issued before winter, and we erroneously took this exceptional occurrence for the rule.

SUMMARY OF THE DISTINGUISHING POINTS COMPARED WITH ALETIA.

The most salient points of difference between the Cotton Worm and the Boll Worm—those which will enable the planter to most readily distinguish between the two insects at any stage of growth—may be briefly summed up as follows:

EGG.—The egg of the Aletia is of a delicate bluish-green color, while that of the Heliothis is dirty white. Although the two eggs are of about the same transverse diameter, the Aletia egg is very flat, while that of Heliothis is conical, its longitudinal being equal to the transverse diameter. Dr. Phares has neatly expressed the difference in shape by likening the egg of Heliothis to an inverted tea-cup, and that of Aletia to an inverted saucer.

LARVA.—The full-grown Boll Worm is somewhat longer and much thicker than the full-grown Cotton Worm. It early loses the looping method of locomotion, which to a certain extent persists throughout life with Aletia. The reason for this is that the front pair of prolegs (on the third abdominal joint) is well developed in Heliothis, while, as we have already seen, it is atrophied in Aletia. The differences in the normal markings are well shown upon the plates, yet certain of the young Boll Worms so closely resemble Cotton Worms that some other distinguishing character than that of stripes is needed. This character is to be found in the piliferous tubercles on the back of both larvæ. Of these, in each species, there are four upon the upper side of each abdominal joint. In Aletia these four spots form the corners of a rectangle. In Heliothis, however, the posterior two are more widely separated than the anterior pair, so that the four form a sort of trapezoid. This character is absolutely constant.

PUPA.—The pupa of Heliothis is always found beneath the surface of the ground; that of Aletia is always above ground and usually inclosed in a nest of silk and enveloped in a leaf. The pupa of Aletia is slender, usually dark brown or almost black in color, and has a dull appearance. The pupa of Heliothis, on the other hand, is stout, light brown in color, and is smooth and shining. The abdomen of the pupa of Aletia, as has already been shown, is elongated and bears on its tip six delicate ex-

*Most of the moths issue in the fall and hibernate as such, but some of them pass the winter in the chrysalis state, and do not issue till the following spring. I have known them to issue in this latitude (38½° north) after the 1st of November, when no frost had previously occurred.

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curved spines. The pupa of Heliothis at the extremity of its abdomen is rounded and bears two long, straight, slender spines.

ADULT.—The differences between the two moths are so well marked and so easily seen by a glance at the plates, that it seems unnecessary to particularize. The Heliothis is a larger and stouter bodied moth than Aletia, although the wing expanse is but slightly greater. Aside from the differences in color and markings, which are so plainly perceptible in two cabinet specimens placed side by side, the Heliothis may usually be distinguished either at rest or during flight by the conspicuous black band on the hinder border of the hind wings, which, as we have already seen, is partly shown by the slight lifting of the front wings, even when the moths are at rest.

NATURAL ENEMIES.

The natural enemies of the Boll Worm, so far as they have been observed, are almost identical with those of Aletia. Among the vertebrates Bats have been seen to catch the moths on the wing at night and devour them, and the smaller animals mentioned in the chapter on the natural enemies of Aletia feed upon Heliothis as well. Domestic poultry seem to have no preference as between the two worms. The following evidence of the good offices of poultry is from Judge Johnson's report:

> But of all birds the most effectual I have found are domestic turkeys and chickens. Turkeys range through a cotton field, looking up into the leaves, and well hid must be the worm they do not find. Their value has long been known in tobacco fields. Chickens, on the other hand, not so good after the worms, are exceedingly active in pursuit of moths.
>
> When two small fields near me, and daily visited this summer, became naturally planted with Aletia the last of August and 1st of September, the neighboring turkeys and chickens were there from morning till evening. They never allowed Aletia to get more than half grown. Even when, on the 20th of September, I brought hundreds of Aletia larvæ into one of them for experiments with pyrethrum, the turkeys hunted them out with superior interest and eyesight. In a few hours none were left, except two, which were old enough to web up before they were found out.
>
> How they should find the Boll Worms so often I do not know. But as a fact it was vain for me to mark stalks with young Heliothis upon them for future observations. The turkeys were there from morning until night, and Heliothis did not dare to show his nose, as he often does at the close of day, without danger from these vigilant guards. Practically I was compelled to cage all I proposed to watch.
>
> To the great planting interest these facts can be of little value. It would require flocks of immense numbers and to be herded about over the fields, to accomplish anything proportionate to what is above related of small patches near habitations.

Probably all insectivorous birds nesting in the South assist in the destruction of Heliothis. As a matter of fact, however, but few observations have actually been made. The King Bird or Bee Martin (*Tyrannus carolinensis* Baird) has been especially mentioned by several observers, as also the Mocking Bird (*Mimus polyglottus* Boie). Concerning these two birds Mr. Glover has said:

> Insectivorous birds also serve as very useful agents in the diminution of the Boll Worm. In proof of this fact I will state that I have seen a king-bird, or bee-martin,

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chase and capture a Boll Worm moth not ten paces from where I stood, and which I was in pursuit of at the same time; also, that some young mocking-birds, kept in their nests near an open window, were fed daily by their parents with insects, among which were quantities of the Boll Worm moth, as was proved by the ground underneath being strewn with their dissevered wings.

In addition to these we may mention particularly the Blue Bird (*Sialia sialis* Baird), the Orioles (*Icterus baltimore* Daudin and *I. spurius* Bonap.), and the Quail (*Ortyx virginianus*).

With regard to the predaceous insect enemies we need hardly do more than refer back to the corresponding foes of Aletia. Mr. Glover has given an account of a small spider, probably a Theridioid, which feeds upon young Boll Worms as they are piercing the involucre, making its nest between the involucre and the boll. Professor Jones has mentioned spiders, Ladybird larvæ (*Coccinellidæ*), *Acanthocephala femorata*, the Wheel Bug (*Prionotus cristatus*), the Spined Soldier-bug (*Podisus spinosus*), and the Tiger-beetles (*Cicindelidæ*). Several of the commoner species of Ground-beetles destroy the worms as they enter the ground to pupate.

With regard to Ants the evidence is contradictory. Professor Jones says: "I never have seen ants eating them [the Boll Worms] in any state, until they had been killed or injured by some other agent, or had died, except when the worms were confined in jars; even this was a very rare occurrence. I think I observed it but twice, and both these instances were at my residence. No instance occurred in the laboratory where my work was done."

Mr. Trelease, however, details a contrary experience in his report made to Professor Comstock in 1879, as follows:

Like the Cotton-caterpillar, the Boll Worm is more abundant in wet than in dry places; at least, such was my experience, and it is also said to do better in wet than in dry seasons. This is readily explained by the hostility of ants, which are more abundant in dry than in wet places, and in fair than in rainy seasons.

Early in June several half-grown "bud-worms" were collected on Indian corn and transferred to cotton-plants with a view to watching their actions. Care was taken to place them upon plants on which there were no ants. Seating myself beside them, I awaited developments. At first they evinced no desire to do more than conceal themselves beneath the leaves from the glare of the sun. But it was not long before a stray ant appeared on the plant, and, finding the larva, proceeded to run round and round it, biting it whenever it could.

Soon, however, finding that unaided it could do little, the ant left the plant, and, after watching it a short time, I lost sight of it; but in a few minutes it returned accompanied by several others of the same species. In a little while the worm was so worried that it fell from the plant, and was soon killed and carried off by its tormentors, which followed it to the ground.

Several times I saw this repeated, the Boll Worm being killed in each case within an hour after the time when they were placed on the cotton. The black ant was also seen to kill these larvæ upon several occasions, and once or twice when the worms had not been interfered with by me.

The truth of the matter probably is that certain species of ants devour the eggs and young of the Boll Worm, as well as an occasional full-grown specimen with the same avidity that they do Aletia.

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Under this head of predaceous enemies we may properly mention Heliothis itself, but we have already given particulars of its cannabalistic habits.

It was thought for a long time that the Boll Worm was absolutely free from true parasites, but this has been proved untrue. Three species of parasites have been bred and undoubtedly more will be found. In 1872 we bred *Tachina anonyma* Riley from *Heliothis armigera*, and mentioned the fact in a foot-note to page 129 of our Fourth Missouri Entomological Report. In 1879 the species of Tachina which we have described as *Tachina aletiæ* (*Canadian Entomologist*, XI, p. 162), and which is also, as the name implies, an important parasite of Aletia, was bred at the Department from a Boll Worm collected at Selma, Ala., by Mr. Trelease. The white eggs of this Tachina have also been observed by Mr. Hubbard at Crescent City, Fla., by Judge Johnson at Holly Springs, Miss., and by Prof. R. W. Jones at Oxford, Miss. The latter says:

> In the latter part of the season a great many larvæ of Heliothis and Aletia bore a white egg which was found to be Tachina. In some instances the moths hatched out notwithstanding the eggs of the parasite. In other cases the chrysalis was destroyed by the grub; the latter was generally the case. Sometimes as many as five eggs of Tachina would be found on one larva of Heliothis or Aletia; more generally on Aletia than Heliothis. This Tachina must be an exceedingly formidable enemy of both Aletia and Heliothis.

It is interesting to note that Tachina eggs were observed on Boll Worms many years ago. Mr. J. W. Boddie, writing in 1850, says (see Bibliographical List): "I cannot account for their disappearance, for the season was favorable. They may have been destroyed by some of the Ichneumonidæ family, perhaps the *white oblong dots* we saw on them. I never saw them on the first brood or their eggs."

The remaining parasite is also one which is common to Aletia. It is the Trichogramma egg-parasite, *Trichogramma pretiosa* Riley (see page 102). It was bred by Mr. Hubbard from the eggs of Heliothis at Crescent City, Fla., and the specimens sent were accompanied by the note: "Eggs of both Aletia and Heliothis parasitized turn black on or by the second day; the Chalcids disclose about 7 or 7½ days from the time the eggs are stung." The only point in which the parasitism of the eggs of the Heliothis will be found to differ from that of Aletia eggs is that, owing to its greater capacity, the egg of Heliothis will probably sustain more of the parasites.

REMEDIES.

Under the head of remedies we may briefly mention in the first place two plans which have had strong advocates for many years. These are topping the cotton and rotation of crops. The first of these plans has been followed by many planters, but it is an easy matter to show, as has been done with Aletia, that the number of eggs laid upon the part of

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the plant which is removed in the process of topping is so small proportionally that their destruction will not pay for the labor expended. With corn, topping might occasionally be of some avail, as it tends to hasten the maturing of the ears, rendering them distasteful to the worms.

Any one who has read the long and varied list of food-plants which we have already given will at once see the objection to the adoption of rotation of crops as a remedy. With food-plants so numerous, a cessation in the growth of one of them, even though it were the principal one, could make no very important difference in the numbers of the Boll Worms. Still many writers have urged this as a sure preventive, and it is a curious fact that a correspondent of the *Southern Cultivator* a number of years ago proposed corn as a most excellent crop to rotate with cotton, never suspecting the identity of the Corn and Boll Worms.

EARLY PLANTING.—In our Third Report on the Insects of Missouri, we expressed the opinion that corn planted very early and very late is more apt to be badly infested than that planted moderately early and moderately late, the early-planted crop being infested by the first brood and the late by the second brood. Professor French, however, in the Seventh Illinois Entomological Report, has detailed a contrary experience, in which late-planted corn fared badly while the early crop escaped. In a bad worm year our rule would undoubtedly hold good; but in an ordinary season, if the corn is planted early and forced to early maturity, the ears will have become hard before the second brood has made its appearance, the first brood not being sufficiently numerous to do any marked damage.

LOW CORN VS. HIGH CORN.—In the *Pacific Rural Press* for September 13, 1879, Professor French put forth the following idea:

I have found for the past two years that where there were two varieties of corn growing near each other, the one tall, with ears five or six feet from the ground, and the other short, the tall corn would be free from worms, while the other would have from 50 to 60 per cent. of the ears waving.* Where the tall corn has been growing by itself there are usually some worms in the ears, but not so many as in fields of a low variety. The reason of this seems to be in the fact that the parent moth does not fly above 3 or 4 feet high if it can find suitable places for depositing the eggs. Probably every one familiar with the moth has noticed that when disturbed or drawn from its retreat in the day-time, the moth starts up from some place not more than 2 or 3 feet from the ground. Now it is evident from these points that if a kind of sweet corn can be had growing tall enough so that its ears shall be, say, 5 feet from the ground, and small patches of some low-growing kind be planted near this, the tall kind will be unmolested while the eggs will be deposited in the ears of the low variety, thus securing corn for the market without worms. The low kind, while not fit for market, need not be a perfect loss, for it can be fed to stock, probably being worth enough for that use to pay for its culture.

FALL PLOWING.—In those localities where the temperature falls low enough every winter to freeze the ground to the depth of six inches, or even less, late fall plowing will undoubtedly destroy most of the hiber-

*The wavy appearance of the shriveled husk is here alluded to.—C. V. R.

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nating chrysalids. Professor French has experimented upon this point, and we quote his results from the *Prairie Farmer* for October 26, 1878:

To see what effect freezing would have upon the chrysalids under different circumstances I obtained quite a number the fore part of last December and treated them as follows, numbering the different lots for convenience: No. 1 I put in loose dirt, moistened a little and allowed to freeze; No. 2 were put in loose dirt of the same character, kept slightly moist, but were not allowed to freeze; No. 3 were placed in segments of the smooth cells or holes from which they had been taken, the dirt of the cells kept as moist as when taken from the field, but no loose dirt allowed to get into the cells round the chyrsalids, and they were allowed to freeze; No. 4, were treated in the same way, but were not allowed to freeze; No. 5, were cared for in a room of about the same temperature all winter and in a way best adapted to keep them from moulding.

After a few hard freezes, and the temperature had become milder, an examination of lots 1 and 3, that had been allowed to freeze, showed that all of lot one were dead, but none of lot 3. Lots 2, 3, 4 and 5 were then placed side by side and cared for alike the rest of the winter, so far as moisture and temperature were concerned, but after a while those of lot 2 were taken out of the dirt and cared for the same as lot 5. These began hatching May 27, of last spring, and continued to come out till July 29, and I could not see as any greater per cent. of lot 5, that had been well cared for all the time, hatched, than 2 or 3.

From the effect of freezing upon those that had been mixed with moist earth, the conclusion was inevitable that fall plowing followed by fall rains and winter freezing would produce the same result, for the plowing must break up their smooth cells and allow them to become surrounded by the loose soil which when wet sticks to them. If frozen in this condition they are evidently easily killed, but so long as their cells remain entire no amount of freezing under ordinary circumstances seems to injure them.

This evidence seems very satisfactory, and in the northern part of the cotton belt at least, as well as in the great corn-growing regions of the West, fall plowing will undoubtedly prove an excellent remedy. In the major part of the cotton belt, however, something else is needed.

DESTRUCTION OF THE MOTHS.—*Lights and poisoned Sweets.*—These remedies have been fully discussed under the head of Aletia, and the reasons for their apparent want of success given. Testimony is not wanting as to their efficacy with Heliothis. Mr. Schwarz, in one of his letters from Texas, describes a simple trap-lantern used by planters in the vicinity of Hearne, Tex., the use of which "proved most effectual against the ravages of the Boll Worm, which in 1877 did more harm here than Aletia, and which was killed in great numbers by this method." Experiments made by Mr. Schwarz during the summer of 1879 at Columbus, Tex., where twenty lamps were watched and the captures tabulated, showed that, although not so abundant, the moths of Heliothis were more readily attracted by the lamps than Aletia, and more were caught in this way. It must be remembered, however, in experiments of this kind, that a large proportion of the moths captured are males, or females which have already deposited their eggs. Mr. Crane, of Mandarin, Fla., who lost in 1878 a large proportion of his crop of tomatoes by Heliothis, in 1879 built fires of light wood in his field with much profit.

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A marked example of the benefit of poisoned sweets is the experience of Colonel Sorsby, as given in the Department of Agriculture Report for 1855:

We procured eighteen common-sized dinner plates, into each of which we put half a gill of vinegar and molasses, previously prepared in the proportion of four parts of the former to one of the latter. These plates were set on small stakes or poles driven into the ground in the cotton-field, one to about each three acres, and reaching a little above the cotton-plant, with a six-inch square board tacked on top to receive the plate. These arrangements were made in the evening, soon after the flies had made their appearance; the next morning we found eighteen to thirty-five moths to each plate. The experiment was continued for five or six days, distributing the plates over the entire field, each day's success increasing, until the numbers were reduced to two or three moths to each plate, when it was abandoned as being no longer worthy of the trouble. The crop that year was but very little injured by the Boll Worm. The flies were caught in their eagerness to feed upon the mixture by alighting into it and being unable to escape. They were probably attracted by the odor of the preparation, the vinegar probably being an important agent in the matter. As the flies feed only at night, the plates should be visited late every evening, the insects taken out, and the vessels replenished as circumstances may require. I have tried the experiment with results equally satisfactory, and shall continue it until a better one is adopted.

The devices which have been invented for entrapping night-flying moths, as well as the compound for attracting them, have already been discussed in Chapters X and XIII, and additional remarks upon these remedies will be unnecessary.

HAND-PICKING.—Indiscriminate hand-picking of the later broods of the Boll Worm upon cotton is, of course, out of the question, but the plan of killing the worms of the first two or even three broods in corn is eminently practicable, and will undoubtedly save the cotton from much of the damage done by the later broods of the worm. On account of the numerous food-plants, extermination would, of course, be impossible, but the early corn crop contains by far the greater part of the earlier broods, and time and labor will be far from lost when we consider how great is the importance of a single individual of the first or second brood in view of its possible offspring. In localities where corn is not grown at all over a large space, as in parts of Texas, it will, we think, pay planters to grow small patches here and there as traps for the early worms. Several of the older writers on the Boll Worm have suggested this plan, among them Colonel Sorsby, Mr. Sanderson, and Peyton King; but, practical as it sounds, it seems never to have been used to any extent.

We have already shown, under the head of food-plants, how the presence of the first brood of the worms in the young corn may be detected by the riddled appearance of the leaves. Similarly the individuals of the second and third broods may be discovered by the excrement at the ends of the ears, by the absence of silk, or by a waving or rippling of the husk in places. Now, if the plow-hands in cultivating the crop be instructed to watch for these signs, and, at their appearance, to stop and destroy the worms, or, better still, if boys be occasionally sent

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hrough the fields to systematically kill all the worms, the effect upon he cotton crop will certainly be noticeable.

POISONING.—Since the introduction of arsenical poisons for the Cot-on Worm the wish that the Boll Worm could be reached by them has nany times been expressed; but, working in the interior of the boll as it loes, it seemed impregnable to a shower of poisoned spray or dust. A nore careful study of the life habits of these worms, however, has shown, as we have already stated, that the young worms feed for a longer or shorter space of time upon the leaf or involucre upon which they were born before seeking to penetrate a boll. It is also true that the larger, even the nearly full-grown worms, in migrating from boll to boll, feed occasionally upon the leaves, and it has been shown that the Boll Worm is as susceptible to the influence of these poisons as is the Cotton Worm. These facts can be easily demonstrated by examining the worms killed in a carefully poisoned field. Many Boll Worms, large and small, will be found among them. Moreover, a boll which has a slight coating of some arsenical mixture is perfectly protected from the worm, if we can believe the statement in the following extract from Professor Stelle's report:

> At the time of the season when the Boll Worm was most actively at work, I made an experiment looking to a decision as to whether or not sprinkling the plants with London purple had any bad effect upon that insect after it had ceased to feed upon the leaves. Selecting several heavily fruited plants, I spread dry London purple carefully over the bolls, applying it thinly with a camel's hair brush. It protected every boll. While a large per centum of the bolls on all the neighboring plants were afterwards bored into, not one to which I had applied the London purple was damaged in the least.

The poisoning for the Cotton Worm, then, undoubtedly accomplishes two ends, in also destroying many Boll Worms. In regions where the latter is especially injurious it may be thought worth while to poison for it alone. In such cases the corn should be carefully watched and the poisoning should be done in one or two weeks after the full-grown worms are seen in bulk in the hardening ears—say, about August 1 in Central Mississippi and Alabama. In these localities the poisoning for the third brood of the Cotton Worm can be done at the same time.

PYRETHRUM.—But, after all, no one of the remedies so far given is absolutely satisfactory in itself. The more promising ones—fall plowing, trap-lanterns, and poisoning—should all be used. The great desideratum is something which shall reach and destroy the worms in the bolls. This pyrethrum seems to promise, if we can judge from the experiment which we had made by Professor Jones and Judge Johnson, and which the latter has detailed as follows:

> Direct applications of poisons to them must be difficult. All the feeders on the external parts of plants succumb to Paris green or London purple. There are none that may not be reached by Pyrethrum in some form.
>
> And this last proposition, from experiments made this fall in company with Professor Jones, or with some of his extracts, I have reason to believe will hold good.

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We collected all the bolls we could find containing Heliothids. At that time, September 23, they were scarce. These, with numbers of Aletiæ, we showered with a wood-spirit extract of Pyrethrum diluted with water at the rate of thirty to one. The Aletiæ fell off the leaves and died in less than ten minutes. In about that time the Heliothids backed out of their holes and crawled about uneasily. In five minutes they, too, fell to the ground.

Doubtless it is by creating in this way an atmosphere deadly to them they were forced to leave their retreats and get upon the wet and fatal leaves. When fields can be sprinkled instead of only a few feet, probably a still weaker infusion will prove effectual. With this extract, then, it becomes only a question of cost to deal with the Boll Worm.

For a full discussion of Pyrethrum, its cultivation and its compounds, see Chapter X.

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EXPLANATION TO PLATES.

PLATE I.

ALETIA XYLINA.

(Original.)

FIGS. 1, 1, 1. Eggs.
FIG. 2. Newly-hatched larva, or first stage: *a*, larva in second stage; *b*, *b*, *b*, larvæ in third stage; *c*, third stage, suspended by silk; *d*, *d*, larvæ in fourth stage; *e*, larva in fifth stage; *f*, larva in sixth or last stage and full-grown, side view and pale form; *g*, same, side view, dark form; *h*, same, back view; *i*, larva in fifth stage, in act of springing.
FIG. 3. Chrysalis just changed and freed of its cocoon: *a*, chrysalis partially covered and ready to give forth the moth; *b*, cocoon entirely surrounding chrysalis.
FIG. 4. Female moth with wings expanded: *a*, same, with wings closed, back view; *b*, male moth with wings closed, side view.
FIGS. 5, 5, 5, 5. Membranous patches of leaf, showing how parenchyma is eaten by young worms. (From Bull. 3, U. S. E. C.)

PLATE II.

(Figs. 7 and 7*a* after Hübner; the rest original.)

FIG. 1. *Anomis erosa*, larva, full-grown, at rest—natural size: *a*, head, from above; *b*, terminal joints and hind prolegs; *c*, one middle joint of body from above; *d*, same, from side—enlarged.
FIG. 2. Same, pupa.
FIG. 3. Same, moth with wings closed: *a*, wings expanded.
FIG. 4. *Anomis exacta*, full-grown larva—natural size: *a*, same, head; *b*, same, anal end; *c*, same, middle joint above; *d*, same from side—enlarged.
FIG. 5. Same, pupa.
FIG. 6. Same, adult, dark variety: *a*, white reniform variety.
FIG. 7. *Aletia argillacea*, adult, wings expanded; *a*, same, under side.

PLATE III.

HELIOTHIS ARMIGERA.

(Original.)

FIG. 1. Egg.
FIG. 2. Young larva.
FIG. 3. Square gnawed into by young larva.
FIG. 4. Pale yellowish larva, with boll gnawed and eaten into.
FIG. 5. Full-grown larva, normal colors.
FIG. 6. Chrysalis in earthen cell.
FIG. 7. Moth with ochreous tints.
FIG. 8. Moth with olivaceous tint.
FIG. 9. Moth at rest, showing how wings remain partly open.

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PLATE IV.

HELIOTHIS ARMIGERA.

(After Glover.)

FIG. 1. Egg, natural size, as deposited on the outside of the involucel or ruffle.
FIG. 2. Holes eaten through the involucel and corolla by the young boll worm, before the flower bud has matured into the perfect flower.
FIG. 3. Young boll worm eating stamen, &c., and causing its destruction.
FIG. 4. Frass dropped by young worms.
FIG. 5. Hole eaten through the bottom of flower into the embryo seed vessel or boll.
FIG. 6. Young worm eating interior of young boll.
FIG. 7. Pistils and stamens destroyed by attack of young worms, and frequently the cause of non-impregnation.
FIG. 8. Young flower-bud as attacked by the young worm, with the interior eaten out.
FIG. 9. Same, as fallen; the involucel always, in planters' phrase, "flaring open."
FIG. 10. Full-grown into full-grown boll—hence another common name, "Bore Worm."
FIG. 11. Parenchyma or cellular tissue of the leaf as eaten by the caterpillar the third day from the hatching of the egg.
FIG. 12. Hole eaten through the involucel the fifth day.
FIG. 13. Size of worm before shedding its first skin.
FIG. 14. Young worm eating the calyx the sixth day, sheltered by the involucel or ruffle.
FIG. 15. Size of worm after first molt.
FIG. 16. Young worm eating the flower bud, the ninth day.
FIG. 17. Size of worm after the second molt.
FIG. 18. Young worm eating into the young boll, the fourteenth day.
FIG. 19. Size of worm when molting the third time, showing the worm in the act of shedding the skin.
FIG. 20. Full-grown boll worm, with hole eaten in seeds of boll after shedding skin the fourth time (nineteenth day), with frass in the boll.
FIG. 21. Boll cut open longitudinally to exhibit injury.
FIG. 22. Worm, natural size, after shedding skin the sixth time.

PLATE V.

LEUCANIA UNIPUNCTA.

(Original.)

FIG. 1. Glistening secretions which often show where eggs are laid between fold of green leaf.
FIG. 2. Young larva.
FIGS. 3, 4, 5. Full-grown larvæ, ventral, dorsal, and lateral views.
FIG. 6. Larva, showing Tachina eggs near head.
FIG. 7. Pupa.
FIG. 8. Moth with wings expanded.
FIG. 9. Moth showing normal position of wings when closed, back view.
FIG. 10. Pale specimen of moth from side.

PLATE VI.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. Longitudinal section of larva: *M*, mouth; *a*, *b*, *c*, legs; *St.*, stomach; *Sal.*, salivary gland; *d. v.*, dorsal vessel; *m. v.*, malpighian vessels; *In.*, intestine; *R*, rectum; 1, 2, 3, 4, 5, false legs; *br*, brain; *g*, *g*, ganglia.
FIG. 2. Second proleg.
FIG. 3. Hook of proleg.
FIG. 4. Third right leg.
FIG. 6. Terminal hook or claw of same leg.
FIG. 7. Wall of the stomach, the epithelium removed: *tr*, trachea; *l*, *l*, longitudinal muscles.
FIG. 8. Cuticula from a dark band of larva.

PLATE VII.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. Longitudinal section of head of larva: *M*, mouth; *f*, frontal ganglion; *br*, brain; *s*, subœsophageal ganglion; *Gl.*, first abdominal ganglion; *Oe.*, œsophagus; *Sp.*, salivary tubercle or spinneret.
FIG. 2. Longitudinal section of head of imago: m^1, m^2, m^3, muscles; *mx*, maxillæ; *Sal.*, salivary duct; *P.*, palpus; *Oe.*, œsophagus; *Br*, brain.

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PLATE VIII.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. Exoskeleton, female imago: *a*, antenna; *cl.*, clypeus; *E*, eye; *P.*, palpus; *mx*, maxilla; *ep.*^{1}, first spiracle; *eps.*^{1}, episternum; *s.*^{1}, scutum of prothorax; *s.*^{2}, scutum of mesothorax; *sm.*^{2}, scutellum of mesothorax; *w*, wing; *st.*, sternum; *cx.*, coxæ; *epm.*, epimera; I, II, III, thoracic segments; 1–9, abdominal segments.

FIG. 2. General anatomy of male imago: *br.*, brain; *œ.*, œsophagus; *ao.*, aorta; *g*, *g'*, *g''*, ganglia; *fr.*, food reservoir; *Ts.*, testis; *st*, stomach; *m. v.*, malpighian vessels; *i*, intestine; *c*, cœcum; *R.*, rectum; *p.*, penis; *a*, clasper; 1–9, abdominal segments; I–III, thoracic segments.

PLATE IX.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. Exoskeleton, ventral view: *p.*, palpus; *mx.*, maxillæ; *E*, eye; *s.*^{1}, scutum (?) of prothorax; *l.*^{1}, joint of first leg; *st.*, sternum; *eps*, episternum; *pt.*, patagium; *a*, *a*, median pieces.

FIG. 1. A. Section of scale.

FIG. 2. Three tarsal joints, leg of imago.

FIG. 3. Long scale from the abdominal brush of the male. (⅛-inch objective.)

FIG. 4. Female organs of reproduction: *a. p.*, copulatory pouch; *v.*, *v.*, vagina; *S. d.*, sperm-duct; *ov.*, base of the four left ovarian tubes; *u.*, the uterine chamber, or expansion of the oviduct; the right oviduct can be seen cut off; *a. v.*, copulatory vestibule; *a. gl.*^{1}, the single and *a. gl.*^{2}, the double accessory gland, only a portion of the tubes being shown; 8, the eighth abdominal segment, the upper part being indicated by dotted lines, so as to show the oviduct beneath; 9., terminal segment with its lateral lobe.

FIG. 5. Cuticle from copulatory pouch.

FIG. 6. Small portion of same, more magnified. (⅛-inch objective.)

FIG. 7. Transverse section through one of the folds of the copulatory pouch (1/12-inch objective): *m*, muscular layer; *ep*, epithelium; *Cu.*, cuticula intima.

PLATE X.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. Reproductive organs of the male, from above: *ts*, testis; *v. d.*, vasa deferentia; *g. m.*, glandulæ mucosæ; *d. e.*, ductus ejaculatorius; *p*, penis; *v. pr.*, ventral process of ninth segment; 9, telson of same; *a*, left, *a*^{1}, right clasp; *b*, brush; *a*, anus; *p. p.*, protractor penis.

FIG. 2. View from beneath of the ninth segment of the male with its appendages. Letters as before.

FIG. 3. Lateral view of same: *f*, movable finger over the anus; other letters as before. The position of the brush is shown by dots, so as to make the shape of the clasp more evident.

FIG. 4. Tip of penis, from above.

PLATE XI.

ANATOMY OF ALETIA XYLINA.

(Original.)

FIG. 1. View of spiracle, abdomen of imago.

FIG. 2. Single spine of same spiracle.

FIG. 3. Exoskeleton of third thoracic and first abdominal segment: *S.*^{2}, scutum; *A.*, flap; *B*, tympanum; *Epm.*^{2}, epimeron; *cx.*^{2}, coxa; *Sp*, spiracle.

FIG. 4. Cuticula of first abdominal segment.

FIG. 5. Pores to which scales are attached.

FIG. 6. Tip of maxilla.

FIG. 7. Hairs of maxilla.

FIG. 8. Single spine from maxilla.

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PLATE XII.

PYRETHRUM ROSEUM.

(From Annual Rept. U. S. Dept. Agr., 1881–'82.)

Showing variation in leaf and in color of flower, as grown by C. V. Riley.

PLATE XIII.

PYRETHRUM CINERARIÆFOLIUM.

(From Annual Rept. U. S. Dept. Agr., 1881–'82.)

Showing variation in leaf, as grown by C. V. Riley.

PLATE XIV.

MANY-PUNCTURED SPRAY-NOZZLES.

(Original.)

FIG. 1. Rose-rim eddy-nozzle with two caps, *ee*; marginal punctures, *s*, and tangent entrance, *aa*.

FIG. 2. Same, with one cap, *c*, and inner rotary brush, *b*, with spray rim, *s*, and tangent inlet, *a*.

FIG. 3. Rose-face eddy-nozzle with punctured side, *s*, cap, *c*, and tangent inlet, *aa*.

FIG. 4. Same, showing usual position on watering pots.

FIG. 5. Rose-arm T-nozzle with inlet, *aa*; sprays, *ss*, for two rows, and stoppered ends, *oo*.

FIG. 6. J. Warner's curved T-rose with inlet, *aa*; arms, *ee*, and spray, *s*.

FIG. 7. W. Westlake's divided rose head with spout, *a*; separable neck, *c*, and rose-face, *s*.

FIG. 8. S. H. Fox's divided strainer-robe with spray cap, *ss*; chamber, *aa*; inside strainer, *oo*; removable on cap, *c*; and inlet, *av*.

PLATE XV.

MANY-PUNCTURED SPRAY-NOZZLES (continued).

(Original or adapted from patent drawings.)

FIG. 1. The Barry and Prentice combination rose and solid jet nozzle (in section) with barrel, *a*, and nib, *d*, for carrying the rose, *b*.

FIG. 2. L. B. Foss's divided rose head, opening at the screw juncture, *d*.

FIG. 3. W. T. Voss's reversible-faced rose with inlet, *a*; chamber, a^1; clamp-ring, *c*; and reversible rose-face, *b*.

FIG. 4. J. W. Johnson's ping rose with inlet, *h*, and outlets, *l* (in section).

FIG. 5. Colliding-jet nozzle of W. J. Daughtrey's machine, having barrel, *N*; outlets, *n*, n^1, and projection, n^2.

FIG. 6. J. P. Ruhmann's rose-rim nozzle, having chamber, *l*, and cap, *m*.

FIG. 7. Same, interior view, showing L-shaped brush (cleaner) in chamber, *l*.

PLATE XVI.

SLOT-NOZZLES FOR SPRAYING.

(Original.)

FIG. 1. Slot-rim eddy-nozzle with cap, *c*; chamber, *v*; side slot, *s*; tangent-inlet, *a*; sheet-metal style.

FIG. 2. Same, with inside lid, *c*; direct discharge, *s*.

FIG. 3. Same, with crosswise slot, *s*; other positions, *svo*, for the slot; arrows indicating internal rotation.

FIG. 4. Small-chambered, slot-rim eddy-nozzle, side view and section; tube, *a*; tangent-inlet, *ao*; beveled front slot, *s*; stopper, *c*.

FIG. 5. Same, with side slot for nether spraying, &c.

FIG. 6. A side-slot tube-nozzle; tube, *a*; slot, *s*; cap, *c*, as adjustable deflecting rim, at *s*; in section.

FIG. 7. Same, adjustable in tube, *a*, having deflector margin at slot, *s*; in section.

FIG. 8. John Schier's single, side-slot cap-nozzle, *a*; closed at *c*; screw-juncture, *x*; slot, *s*.

FIG. 9. John Schier's triple, side-slot cap-nozzle; presenting 3 slots.

FIG. 10. John Schier's adjustable-slot cap-nozzle; inlet part, *a*; lever, *t*; slot, *s*; adjustable part, *c*.

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PLATE XVII.

SLOT-NOZZLES FOR SPRAYING (continued).

(Figs. 1–2 original, 3–6 adapted from patent drawings.)

FIG. 1. Double-slotting, double-deflecting, side-slot tube-nozzle; doubly slotted, adjustable deflector cap, *cr*; inner and outer slots, *ss*; tube, *a*.

FIG. 2. A double-deflecting, side-slot tube-nozzle in section; tube, *a*; cap, *cr*; adjustable slots, *s*.

FIG. 3. The B. R. Moffett jawed slot-nozzle; tube, *a*; slot, *s*; adjustable lip, *b*; jaw, *y*; fulcrum, *fr*; lever, *l*; spring, *u*.

FIG. 4. The L. B. Smith jawed slot-nozzle, for solid jet and sprays; slot, *s*; adjustable jaws, *yc*, with arms, *xx*, hinged, at *oo*, to tube, *za*, having clamp nut, *b*.

FIG. 5. The Raymond and Perkins slot-nozzle, for solid jet and spray; tube, *ab*; shut-off, *d*; slot, *s*; barrel, *fs*.

FIG. 6. Same in section; lettered the same.

PLATE XVIII.

SLOT-NOZZLES FOR SPRAYING (continued).

(Original.)

FIG. 1. Adjustable, flanged, slot-rim nozzle with screw cap, *c*; tube, *a*; flange, *s*; rim, *r*; slot, *rp*.

FIG. 2. Divided, flanged, slot-rim eddy nozzle with projectile cleaner inside; tangent inlet, *a*; lower half, *v*; upper half, *c*; slot between, *s*; combining screw, *w*; annular chamber, *h*; projectile, *t*; flange, *p*; in section.

FIG. 3. Same with diverging slot; lettered the same.

FIG. 4. The J. P. Ruhmann adjustable lipped slot-nozzle; pipe, *a*; slot, *s*; lip, *p*; thumb-screw, *t*; arm, *bk*.

FIG. 5. Same, with trigger adjustment; trigger, *l*; spring, *r*; fulcrum, *f*; lip, *p*; slot, *s*; tube, *aw*; stop, *n*.

PLATE XIX.

DEFLECTOR SPRAY NOZZLES.

(Original.)

FIG. 1. Constricted, double-spray deflector-nozzle; pipe, *a*; discharge, *x*; divergent deflectors, *pp*; septum and brace, *ff*.

FIG. 2. Angle-plate, double-spray deflector-nozzle; pipe, *a*; discharge, *x*; deflectors, *pp*; recurved base angles, *vv*; septum and brace, *f*.

FIG. 3. Circular, double-spray deflector-nozzle; pipe, *a*; discharge, *x*; deflector wings, *pp*; fork-aperture, *f*; brace, *ff*.

FIG. 4. The J. P. Ruhmann single-spray, removable deflector, and solid jet nozzle; pipe and discharge barrel, *aa*; separable ring, *uz*; deflector, *p*.

FIG. 5. Same, not removable; a modified form showing median convexity of the deflector, *p*, which joins, at *x*, the nose-piece, *aa*.

FIG. 6. The P. C. Lewis retractile deflector and solid jet nozzle; barrel, *a*; discharge, *s*; bands, *ru*; retracted deflector, *p'*.

FIG. 7. Same, same, with deflector, *p*, exserted; lettered the same.

PLATE XX.

SIMPLE PATTERN SPRAY DEFLECTORS.

(Original.)

FIG. 1. Convex-front, constricted deflector-nozzle; tube, *a*; deflector, *p*; constricted sides, *hh*; median upward and forward curved flange, *f*.

FIG. 2. Straight, flange-front, deflector-nozzle of Mr. Campbell; pipe, *a*; deflector, *p*; raised front, *f*.

FIG. 3. Median-flanged, constricted deflector-nozzle; pipe, *a*; deflector, *p*; mid-flange, *f*; constricted sides, *h*.

FIG. 4. Convex-faced, constricted deflector-nozzle; tube, *a*; convex face, *p*; constricted sides, *hh*.

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PLATE XXI.

DEFLECTOR-NOZZLES WITH SOLID JET.

(From patent drawings.)

FIG. 1. The R. Hollings adjustable deflector-nozzle; barrel, *B*; deflector, *A*; hinge, *s*; arm, *H*; set-screw and link, *DE*.

FIG. 2. The A. Nickerson deflector-nozzle, in section; barrel, *A*; deflector, *B*; raised side, *a*; hinge, *c*; set-screw, *D*.

FIG. 3. The J. T. Hayden deflector-nozzle, in sections; barrel, *Ab*; shut-off plug, *B*; its bore, *c*.

FIG. 4. The J. W. Killam deflector-nozzle; pipe, *A*; socket, *B*; deflector, *E*; raised sides, *D*.

FIG. 5. The J. A. Barrett deflector-nozzle; barrel, *s*; clamp, *dd*; deflector, *abc*; spray, *s*.

PLATE XXII.

TEXAS DEFLECTOR-NOZZLES.

(Original.)

FIG. 1. J. N. Binkley's round-plate deflector-nozzle; supply-pipe, *c*; discharge-pipe, *d*; deflector, *s*.

FIG. 2. J. P. Ruhmann's "improved" cone-deflector-nozzles; discharge-pipe, *a*; deflecting cone, *b*; brace, *c*.

FIG. 3. Same, same, showing the spray.

FIG. 4. John Schier's triple-discharge, distal-plate deflector-nozzle; barrel, *a*; nose-piece, *b*; discharge-nipples, *ccc*; deflector, *d*; attachments, *efgh*.

FIG. 5. Same, with parts separated; lettered the same.

FIG. 6. Same, in operation, showing the spray.

PLATE XXIII.

TEXAS DEFLECTOR NOZZLES (continued).

(Figs. 1-2 original; 3-4 adapted from patent drawings.)

FIG. 1. John Schier's many-jet proximal deflector, with drip returner; supply-pipe, *aa*; nose-piece, *x*; air chamber, *c*; discharge nipples, *jjj*; crescent deflector, *p*; its separable attachment, *uii*; drip pan with return tube, *rr*.

FIG. 2. Same, without nipples, &c., with annular flange deflector; nose-piece, *a*; chamber, *k*; air cavity, *c'*; discharge orifices, *oooo*; deflector, *p*.

FIG. 3. A. J. Polansky's ditto; tube, *f*; chamber, *k*; cap, *c*; discharge holes, *oooo*; deflector rim, *k*; drip pan, *b*; brace, *l*.

FIG. 4. Same, top view; lettered the same.

PLATE XXIV.

EDDY-CHAMBER SPRAY-NOZZLES.

(Original.)

FIG. 1. A simple eddy-chamber nozzle; face view and section; tangent-inlet, *ax*; interior chamber, *ycv*; involute rotation within and tangent radiation of discharge shown by arrows at *s*, the outlet.

FIG. 2. Same, with larger discharge hole but inlet the same, in perspective; lettered the same.

FIG. 3. Same, the chamber, *c*, having a spiroid swell to the inlet, *x*; lettered the same.

FIG. 4. Same, having an oblique facial tangent-inlet, *ax*, to the chamber, *c*.

FIG. 5. Same, having an oblique basal tangent-inlet, *ax*, to the chamber, *c*.

FIG. 6. Diagram section of a whistle jet nozzle, much enlarged; tangent-entrance, *ax*; chamber, *c*; discharge, *s*; the blast shown by arrows.

FIG. 7. Exterior of the same; inlet, *ax*; removable stopper, *c*; discharge, *s*.

PLATE XXV.

EDDY-CHAMBER SPRAY-NOZZLES (continued).

(Original.)

FIG. 1. Eddy-chamber nozzle or cyclone jet of convenient size and form for nether-spraying, face view; tube, *a*; inlet side, *x*; inside lid, *c*; discharge, *s*.

FIG. 2. Same, with lid, *ss*, beneath and opposite discharge, *s*.

FIG. 3. Same, with beveled medium sized discharge, *s*, in the lid, *c*, exterior face view and section; tube, *a*; tangent-inlet, *x*; filling, *k*; chamber, *c*.

FIG. 4. Same, with inside lid beneath and opposite large discharge, side view and section; lettered the same.

FIG. 5. Eddy-chamber nose-piece, *s*, separable, at *j*, from barrel nozzle, *a*.

FIG. 6. Same, with inside bevel, side view and section; tube, *a*; tangent-inlet, *x*; chamber, *c*; inside lid, *s*.

FIG. 7. Same, with spiroid cone chamber, side and top view; tube, *a*; inlet-side, *x*; discharge, *s*.

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PLATE XXVI.

EDDY-CHAMBER AND BARREL SPRAYERS.

(Figs. 1-5 original; 6 adapted from patent drawings.)

FIG. 1. Removable-faced eddy-chamber nozzle with shut-off handle and implanter, in section; tube, *a*; tangent-inlet, *x*; chamber, *c*; removable face, *f*; bugle discharge, *s*; annular flanged rim, c^1; basal inside lid, *es*; stopper screw, *w*; handle and implanter, *v*.

FIG. 2. Direct eddy-chamber sprayer, reversible style, with shut-off, in section; entrance, *wa*; ante-chamber, *b*; packing, *j*; tangent-inlet, *x*, to eddy-chamber, *c*; discharge, *s*; outside cap, ic^1; inside lid, *s*; inversely used; entrance, *s*; ante-chamber, *c*; eddy-chamber, *b*; discharge, *a*.

FIG. 3. Combination eddy-chamber and barrel nozzle, for direct and side spray and solid jet, partly in section; entrance, *a*; barrel, *j*; hollow shut-off plug, *b*; cross-perforation, *n*; chamfer, tangent-inlet, *x*, to 2d eddy-chamber, *c*; inside lid, *f*; discharge, *s*; imperforate inside lid, *e*, exchangeable with discharge lid, *f*.

FIG. 4. Whistle-jet, eddy-chamber nose-piece, in section; screw-juncture, *a*; tangent-inlet, *x*; reverberatory chamber, *c*; discharge, *s*.

FIG. 5. The W. M. Clark spray and solid jet barrel nozzle, in section; entrance, *a*; canal, *xrx*, perforating rotary case, *zzz*; discharge, *s*; nose-piece, *w*; packing, *o*; base-piece and septum, *n*.

FIG. 6. The J. W. Gray spray and solid jet nozzle, partly in section; entrance, *a*; barrel, *is*; plug-hole, *o*; spiral grooves, *es*.

PLATE XXVII.

ROTARY THROWERS AND BLOWERS OF POISONS.

(Fig. 3 adapted; other figures original.)

FIG. 1. Rotary brush powder thrower, diagrammatic section; powder case, *p*; slotted, hinged base, *s*; rotary brush, *d*; semi-cylinder case, *odo*; powder spray, *s*.

FIG. 2. Same, brush in section.

FIG. 3. The Wisewell rotary brush liquid thrower; wheelbarrow, *amnc*; pulley arrangement, *fjkl*; operating stirrer, *ob*, in receptacle, *s*; cock, *q*; pipe, *p*, to brush trough, *F*, belt, *gk*, to brush pulley.

FIG. 4. Horse rotary powder blower, with divergent pipes and nether fork-sprays; adjustable A-frame, *zzz*; iron legs, *ttt*; swivel wheels, *mm*; shafts, *k*; drive-wheel, *w*; drive-gear, *u*; band pulley, *j*; powder-box, *p*; discharge cones, *kkk*; adjustable pipes, *i*; fork-spray nozzles, *gss*.

FIG. 5. Suspended rotary powder blower, operated by hand, fan-chamber, *d*; powder, *p*; blast-pipe, *i*; sprays, *s*.

FIG. 6. Rotary liquid spray thrower and blower, parts in diagrammatic section; fan-chamber, *d*; one of the fans, *f*; its hook-toothed end, *i*; liquid-inlet, *s*; liquid blast spray discharge, *s*; hollow lip, *h*; return drip passage, *hs*.

PLATE XXVIII.

ROTARY BLOWERS OF POISONS.

(Figs. 1-5 original; Figs. 6-7 adapted from patent drawings.)

FIG. 1. Rotary hand blower, can and pipe in section; handle, *o*, on crank gear, *c*; driven gear, *n*; fans, *aa*; brace, *r*; fan case, *d*; blast-pipe, *ss*; powder box, *p*; screw-cap, *c*; hanging base, *b*; adjustable thumb-screw hangers, *tt*; feed slots, *s*.

FIG. 2. Cross-section of the powder feeder; screw-cap, *c*; powder box, *p*; hanging base, *b*; feed slots, *s*.

FIG. 3. Same, with feeder on the fan case, *dd*; discharge, *s*; hanging base, *b*; hangers, *tt*; slot, *s*.

FIG. 4. Side feeder to the same; fan or blast passage, *f*; feed slot, *o*; powder receptacle, *p*; cap, *c*.

FIG. 5. Base feeder to the same; explanation the same.

FIG. 6. The D. E. Darnell rotary liquid blower; frame, *B*; receptacle, *A*; dasher, *C*; gearing, *DEFHJ*; shaft, *K*; blower and adjusters, *LMNWY*.

FIG. 7. Same, side elevation; lettered the same.

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PLATE XXIX.

ROTARY BLOWERS OF POISONS (continued).

(Adapted from patent drawings.)

FIG. 1. The C. T. Hurd rotary powder blower, "sectional elevation;" frame, *D pw K*; wheel, *C*; axle, *m*; band-wheels, *ik*; blower, *B*; powder box, *A*; adjusters, *db*; discharge, *x*; side-wing, *E*.

FIG. 2. Same, "plan view;" lettered the same.

FIG. 3. Same, "rear view;" lettered the same.

FIG. 4. The M. Peel rotary vapor blower; side elevation and section; wheels, *GG*[1]; gearing, *hij*; drum and fan, *de*; blast pipe, *E*; oven, *C*; generator, *D*; fume blast pipe, *G*[1]; nozzle, *mm*.

PLATE XXX.

OSCILLATING BELLOWS BLOWERS OF POISONS.

(Adapted from patent drawings.)

FIG. 1. The S. D. Allen bellows duster, side elevation; frame, *Bg*; wheel, *s*; ratchets, *rr*; ratchet lever, *p*; bellows, *D*; spring, *e*; arm, *f*; blast pipe, *d*; powder receptacle, *A*; discharge pipe, *a*; spreader, *b*.

FIG. 2. Same, powder feeder, in longitudinal section; bellows, *D*; blast, *m*; studs, *n*; partitions, *i*; perforations, *mm*; discharge tube, *a*; spreader, *b*.

FIG. 3. Same, same, cross section, showing the partitions.

FIG. 4. The W. P. Peck bellows liquid sprayer, showing suspended can, connecting pipes and spray.

PLATE XXXI.

SIMPLE BELLOWS NETHER POISONERS.

(Reprinted from Rept. Entomologist Dept. Agr. for 1883.)

FIG. 1. Direct hand-bellows powderer for broadcast and upward use; bellows, *v*; hollow handles, *hh*; blast pipe, *hs*; feed-adjuster, *j*; powder receptacle, *p*; screw-cap, *y*.

FIG. 2. Same, feed arrangement in section; blast-pipe, *sr*; damper and slots, *o*; set-crank, *j*; receptacle, *p*; cap, *y*.

FIG. 3. Triple crook, bellows nether powderer; nether-pipe, *rsluls*; for discharging upward beneath cotton plants; other letters the same; bellows omitted.

FIG. 4. Straight-pipe bellows nether-powderer; bellows, *v*; handles, *hh*; head, *j*; suction gauze and valve, *z*; blast pipe, *hts*; coupling, *hr*; feed adjuster, *j*; receptacle, *p*; cap, *y*.

FIG. 5. Suspension bellows powderer; plug, *y*; suspended receptacle, *p*; bellows, *j*; handle, *h*; valve gauze, *z*; blast pipe, *hsrc*.

FIG. 6. Straight-pipe, bellows nether-atomiser; bellows, *v*; hollow-handles, *hh*; valve gauze, *z*; blast-pipe, *hty*; liquid blast pipe, *yis*; coupling joints, *r*; spray, *s*; liquid receptacle, *p*; stopper, *l*; apex, *x*; bases, *an*.

FIG. 7. Same, receptacle and feeder, in section; receptacle, *pan*; bases, *an*; filling-tube, *l*; ejection-tube, *xy*; blast-tube, *y*.

FIG. 8. External view of same, with mouth-piece.

PLATE XXXII.

SIMPLE BELLOWS, NETHER AND DIRECT POISONERS.

(Original.)

FIG. 1. The J. W. Hendley bellows powderer.

FIG. 2. Nose-piece and single-cone receptacle, of common sanding and powdering bellows of manufacturers.

FIG. 3. Common double-cone sanding and powdering bellows of manufacturers.

FIG. 4. Common atomizer bellows of the trade.

FIG. 5. Nether-can, bellows atomizer; bellows, *v*; blast pipe, *jis*; can, *rp*; filling tube, *l*, or *s*; ejection-tube, *xy*; blast spray, *s*.

FIG. 6. Colliding-blast bulb-atomiser, in section; bulb, *v*; valve, I; blast-way, *hh*; liquid blast, *yis*; receptacle, *p*; ejection-tube, *xy*.

FIG. 7. Nose-piece with side slot discharge, *s*.

FIG. 8. Recurrent blast powder receptacle, with tangent inlet and outlet.

FIG. 9. Recurrent-blast nozzle, as a nose-piece to straight discharge pipes.

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PLATE XXXIII.

COMPOUND BELLOWS POISONERS.

(Original.)

FIG. 1. Wheel ratchet bellows, &c.; bellows, *v*; hangers, *oo*; spring, *s*; arm, *x*; ratchet pitman, *r*; wheel, *w*; discharge valve, *o*; poison receptacle, *p*; divergent pipes, *a*.

FIG. 2. Large can, fork-spray bellows; bellows, *v*; receptacle, *p*; stiff or flexile pipe, *i*; and fork, *g*; sprays, *s*.

PLATE XXXIV.

FLOW BELLOWS-POISONER.

(Original.)

Bellows, *v*; arc, *x*; foot rod, *n*; receptacle, *p*; flexile or stiff segment, *z*; pipe, *i* spray, *s*.

PLATE XXXV.

PNEUMATIC PRESSURE SPRAYERS.

(Fig. 2 adapted; other figures original.)

FIG. 1. Double acting pneumatic pump sprayer, parts in section; pump handles, h, h^1, h^2, h^3; inlet valves, *oo*; double acting valve-head piston, *a*; cylinder, *vv*; discharge, *us*; barrel, *r*; liquid, *p*; outlet pipes, *wmn*; spray nozzles, *ss*.

FIG. 2. An available style of common air pump of the trade; supporting board, *b*; brackets, *oo*; handle, *l*; link, *i*; piston rod, *r*; cylinder, *c*; spout, *s*.

FIG. 3. Compact gas-generator sprayer; acid bottle, *a*; outer vessel and bicarbonate, *b*; cap, *c*; flexile pipe, *ax*; gas, *r*; liquid, *p*; pipe, *mm*; nozzles, *ss*.

FIG. 4. Bipartite gas-generator sprayer; acid bottle, *a*; flexile pipe, *h*; inlet, *j*; bicarbonate vessel, *b*; gas hose, *ax*; &c.

FIG. 5. Foot-bellows pressure sprayer; bellows, *v*; pedal, *l*; hose, *k*; nozzles, *ss*; &c.

PLATE XXXVI.

THE W. J. DAUGHTREY WHEELED ATOMIZER (continued on Plate XXXVII).

(Original.)

PLATE XXXVII.

THE W. J. DAUGHTREY WHEELED ATOMIZER (continued), AND THE C. STEINMANN VAPORIZER.

(Adapted from patent drawings.)

FIG. 1. The W. J. Daughtrey wheeled atomizer, axle; extensile slide socket, e^2; pin, e^3; connections with the body and wheels.

FIG. 2. Same, section view; wheel, *B*; axle, eO^1 pulley, *EDF*; frame, *A*; shafts, *fe*; agitators, f^2; barrel, *G*; eccentric, *H*; pumps, *I*; pipe, *i*; perforations, i^2; air vessel, *J*; main pipe, *m*; nozzle, *N*.

FIG. 3. Same, nozzles, in section; barrel, *N*; inside promontory, n^2; colliding-jet holes, *nn*.

FIG. 4. The C. Steinmann wheeled vaporizer (steam-oil atomizer), side view; seat, *P*; boiler, *F*; oil-pipe, *k*; oil reservoir, *A*; steam-pipe, *CM*; spray pipes, *ss*; cocks, *DHE*; funnel, *B*.

FIG. 5. The same, rear view; lettered the same.

PLATE XXXVIII.

METHOD OF POISONING WITH HYDRONETTES.

(From the Report on Cotton Insects, Dept. Agr., 1879.)

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PLATE XXXIX.

SIMPLE, LIQUID-POISON, NETHER-SPRAYERS.

(Reprinted from Report of Entomologist, Dept. Agr., for 1883.)

FIG. 1. Nether-spraying, hand-pump apparatus; shoulder-loops, *b*; suspended receptacle, *k*; hose, *rhc*; double-acting pump, *cx*; extension-pipe, *i*; nozzle and spray, *s*; joint, *u*.

FIG. 2. Same, substitutive, side-spray, eddy-chamber nozzles, face view and section; neck, *a*; tangent-inlet, *x*; chamber-face, *s*; base, *c*; discharge, *s*.

FIG. 3. Same, substitutive, direct-spray, eddy-chamber-nozzle, *f*.

FIG. 4. Same, double-armed extension-pipe and trailing-fork; stem-pipe, *l*; Y-fork; removable protector, *cj*; spring rods *sys*; arm-pipes, *i*; nozzles, *n*; their swing, *mm*.

FIG. 5. Same, same, curved form.

PLATE XL.

HAND-PUMP AND BUCKET-PUMP SPRAYERS.

(Figs. 1, 2, 3, adapted from patent drawings; 4, 5, 6, original.)

FIG. 1. The aquapult bucket-pump; cylinder, *k*; clawed bracket, *b*; piston-tube, *p*; handle, *t*; hose, *h*; nozzle, *n*.

FIG. 2. The W. J. Johnson bucket-syringe; suction hose, *zhto*; cylinder, *k*; piston handle, *m*; extra nozzle, *n*.

FIG. 3. The aquaject bucket-pump.

FIG. 4. The W. T. Vose Hydropult; suction hose, *h*; cylinders, *kk*; piston handle *m*; air-chamber, *a*; spout, *s*.

FIG. 5. Eddy-chamber hand-pipe as stiff extension to pump spouts or hose; union, *c*; joint, *a*; swivel-neck, *o*; spray, *s*.

FIG. 6. Double-acting side-ejector hand-pump with same; crooked hose nib, *i*; cylinder cap, *c*; piston handle, *hm*.

PLATE XLI.

DIVERS LIGHT SPRAY-PUMPS.

(Fig. 1 original; figs. 2, 3, adapted.)

FIG. 1. Horse-back broadcast spraying apparatus; the eddy-chamber sprayer extension pipe and hand pump (of Plate XXXIX, Fig. 2) combined with the J. Warner rubber poison bags.

FIG. 2. The C. G. Korth crutch bucket-pump in operation.

FIG. 3. The P. C. Lewis combination bucket-pump and syringe.

PLATE XLII.

LIGHT BARREL-PUMPS AND TANK-PUMPS.

(Figs. 4, 5, original; other figures adapted from patent drawings.)

FIG. 1. The F. A. Helmeck air-jacket, return drip barrel-pump; lever, *c*; link-fulcrum, *m*; piston, *b*; cylinder, *a*; suction-valve, *v*; ejection-valve, *d*; air jacket chamber, *e*; discharge, *ff*; drip-duct, *f*.

FIG. 2. The J. G. Evenden ditto; handle, *h*; piston, *b*; ejection valve, *l*; jacket air-chamber, *e*; discharge, *a*; drip-ducts, *mm*.

FIG. 3. The T. K. Ball agitator barrel-pump, partially shown; suction orifices, *h*; cylinder, *b*; piston rod, *c*; dasher rods *dd*; dashers, *kk*.

FIG. 4. The John Schier return drip tank-pump; lever link-fulcrum, *s*; piston-rod, *yy*; cylinder, *e*; suction base, *b*; discharge pipe, *a*; nozzle, *n*; insertion-collar, *c*.

FIG. 5. The C. Vogelsang spray-pump; handle *h*; cylinder, *b*; suction, *a*; air-chamber, *d*; discharge-pipe, *c*.

FIGS. 6, 7, 8. Spray nozzles with the same.

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PLATE XLIII.

LIGHT BARREL-PUMPS.

(Figures adapted from patents.)

FIG. 1. The Yeager air-jacket, barrel-pump and nozzle; barrel, *b*, in section; fulcrum, *i*; lever, *f*; piston rod, *p*; air-chamber and cylinder, *k*; drip-tube, *j*; spout, *s*; nozzle, *n*; caps, *cc*; spray, *s*.

FIG. 2. The F. T. Pinter geared ditto; barrel, *b*; gearing, *fh*; piston, *p*; cylinder, *c*; outlet, *x*; air-chamber, *l*; spout, *ss*; cock, *v*; nozzle, *n*.

FIG. 3. Nozzle to same; face view, *n*; front view, *r*.

PLATE XLIV.

"FOUNTAIN PUMP" AND RUHMANN'S PUMP.

(Fig. 2 original, the rest adapted from patents.)

FIG. 1. "Fountain pump."

FIG. 2. The J. P. Ruhmann "improved atomizer" pump; air-chamber, *c*; 3-branched spout, *a*; hose, *b*; nozzles and sprays, *c*.

FIG. 3. Same, spout in face view.

FIG. 4. Same, cylinder and air-chamber, in side view.

FIG. 5. Same, with his old style nozzle, all complete in reservoir, partially in section; reservoir, *a*; suction strainer, *f*; suction-pipe, *s*; piston, *e*; cylinder, *b*; air-chamber, *i*; lever, *d*; spout, *h*; nozzle, *lm*.

FIG. 6. Same, strainer in section; walls, *f*; cloth, *g*.

PLATE XLV.

AVAILABLE CAST CISTERN AND BARREL PUMP.

(Adapted from patents.)

FIG. 1. The "Lotus No. 1," cistern force-pump; lever, *l*; axis, *s*; upward closed outlet, *n*; cap, *a*; cylinder, *c*; flange base, *f*; suction-pipe, *k*; cock, *x*; discharge, *z*.

FIG. 2. Smallest size common standard cistern force-pump; lever, *l*; fulcrum, *f*; piston rod, *j*; cylinder, *s*; base flange, *y*; suction pipe, *x*; spout, *s*; faucet discharge, *k*.

FIG. 3. Smallest common "Goose-neck" cistern force-pump; lever, *l*; fulcrum, *s*; piston pitman, *j*; cylinder, *c*; base flange, *f*; suction pipe, *k*; spout, *xyz*.

FIG. 4. Double-cylinder barrel or tank pump; base, *mn*; standard, *f*; fulcrum, *s*; pistons, *pp*; cylinders, *bs*; suction, *k*; discharge neck, *cc*; spout, *c*.

PLATE XLVI.

STIRRER-PUMP AND NETHER-SPRAYING MACHINERY.

(Original; used in advance in Rep. of the Entomologist, Dept. Agr., 1881-'2, Pl. IX.)

FIG. 1. Barrel rest or skid; cleats, *bb*; side rests, *aa*; chamfer, *cc*.

FIG. 2. Stirrer pump with barrel and mixer funnel in section; funnel, *u*; its cylindrical sides, *gg*; funnel base, *tt*; spout, *p*, (in bung hole, *k*); gauze septum, *d*; barrel, *kk*; trunnions, *i*; trunnion-eyes, *s*; wedges, *vv*; lever fulcrum, *f*; pump-lever, *ii*; swing of the lever-head and piston top, *abc*; packing-cap, *e*; cylinder, *g*; its swing, *x*; spout, *s*; strainer loop or eye, *h*; stirrer bar, *mn*; rope, *ww*; bungs, *rz*.

FIG. 3. Wagon or cart machine for spraying from below with stirrer pump all in operation; suspension pipes, *t*; Y-forks, *y*; nozzle-arms, *i*, flexile, at *s*; nozzles and sprays, *n*.

PLATE XLVII.

LARGE A-FRAME, NETHER-SPRAYING MACHINE TO WAGON (all in operation, poisoning 16 rows at once).

(Original.)

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PLATE XLVIII.

LARGE A-FRAME, NETHER-SPRAYING MACHINE TO WAGON (narrowed for passing gates, etc.).

(Original.)

PLATE XLIX.

CONSTRUCTIONS IN NETHER-SPRAYING MACHINES.

(Original.)

FIG. 1. A-frame and tubing separated; side arm, *a*; splice, *zl*; set-bar, *z*; main Y-tube, *w*; side-tubes, *mm*; small Y-tubes, *cc*; stem-pipes, *t*; arm-forks, *y*; row-arms, *n*; rows, *rr*.

FIG. 2. Pendant fork with distal nozzles; hose *h*; stem-pipe, *t*; weight cylinder, *s*; arm-fork, *y*; row-arms, *jj*; hose part, *ele*; nozzles, *n*; their swing, *mmm*; inside rod, *s*.

FIG. 3. Swivel-armed pendant fork, in section; stem-pipe, *t*; eddy-chamber, *f*; tangent entrance, *o*; cap-unions, *ee*; arms, *tb*.

FIG. 4. Sheet-metal pendant fork-pipe, in section; stem-pipe, *t*; hose unions, *e*; arms, *t*; spring rod, *ss*.

FIG. 5. Cast weighed fork, in section; Y-casting, *y*; thin inserted tubes, *tjj*; inserted rods, *cs*.

FIG. 6. Pendant, stiff T-pipe, with curved nozzle arms; stem-pipe, *t*; hose joint, *h*; T-head, *eey*; arms, *t*; nozzles, *n*.

FIG. 7. Reverberatory pipe fork; tangent stem pipe, *f*; reverberatory chamber, *g*; arm-pipes, *bb*.

FIG. 8. Small Y-pipe or direct pipe fork; direct arm pipe, *f*; divergent arm pipe, *b*; filling, *v*.

FIG. 9. Adjustable main arm pipe, in section; hose segments, *h*; inserted, direct-fork segments, *m*; telescopic joints, *pp*; divergent pipe arms, *b*.

FIG. 10. Stiff ditto; outside segment, *m*; inside segment, *bm*; hose sheath, *h*; divergent pipe arms, *b*.

FIG. **. Weighty stem pipe, with inserted nipples and basal screw plug.

FIG. *. High-arched wheel-leg with hub-bolt below and swivel-bolt hole at top.

PLATE L.

WHEELED-TRIPOD, AUTOMATIC NETHER-SPRINKLER (in operation, sprinkling twelve rows; showing tripod barrel elevator, tricycle frame, and divergent pipes).

(Original.)

PLATE LI.

WHEELED NETHER-SPRAYER.

(From patent drawings.)

FIG. 1. Rear view; axle, *B*; tank, *A*; chain wheel pump motor, *eidg*; wheels, *RD*; chain, *i*; brace, *j*; crank, *f*; clutch-lever, *h*; pitman, *e*; pump lever, *c*; fulcrum, *d*; piston link, *b*; piston rod, *a*; pump-cylinder, *O*; main arm pipes, *F*; swivel-elbow, *k*; main arm extension, *m*; pendant pipes, *G*; rose-nozzles, *H*; plug, *e*; lifting bar, *I*; clamps, *p*; lifting lever, *n*.

FIG. 2. End view; wheel, *B*; tank, *A*; pump-cylinder, *O*; piston rod, *a*; lever link, *bc*; swivel elbow, *k*; clamp, *p*; pendant pipe, *G*; rose-nozzle, *H*; plug, *l*; lifting lever, *konp*.

FIG. 3. Pump-motor in side view; chain wheel, *RD*; chain, *i*; crank, *f*; pitman, *e*; lever attachment, *c*; clutch, *k*; lever, *h*; brace, *jj*.

FIG. 4. Rose-nozzles, *H*; plug, *l*; perforations in rows.

FIG. 5. Swivel elbow, *k*, and pendant couple, F.

PLATE LII.

C. G. JONES' LARGE TANK BROADCAST SPRAYER.

(Original.)

PLATE LIII.

THE J. W. JOHNSON WHEELED SPRINKLER (rear view in operation).

(Original.)

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PLATE LIV.

WHEELED COTTON SPRINKLER.

(Fig. 5 original; the rest adapted from patents.)

FIG. 1. The J. W. Johnson Cotton Sprinkler, side view; wheel, *c*; frame, *B*; leg, *D*; tank, *A*; pitman, *E*; crank, *e*; piston rod and lever, *G*; pump and spout, *H*; cock, *j*; compare Pl. LIII.

FIG. 2. The same, top view; wheels, *C*; frame, *B*; tank, *A*; pump, *G*; crank, *c*; nozzles, *K*; plug, *l*.

FIG. 3. The J. P. Goodin Cotton Sprinkler, side view; tank, *A*; pump lever, *D*; fulcrum, *E*; piston rod, *C*; main pipe, *B*; main arm pipe, *F*; nozzle arms, *G*; nozzles, *H*.

FIG. 4. Same, top view; lettered the same and explained the same.

FIG. 5. The J. N. Binkley Cotton Sprinkler; pump cylinder, *a*; spout, *A*; air-chamber, *b*; T-pipe, *c*; with sprays.

FIG. 6. The George Yeager Cotton Sprinkler, side view; frame, *A*; reservoir, *E*; suction pipe, *C*; pump cylinder, *D*; sprinkling pipes, *GHI*; piston, *B*; lever, *F*.

FIG. 7. Same, top view; lettered and explained the same.

PLATE LV.

SMALL BUCKET AND KNAPSACK SPRINKLERS.

(Adapted from patent drawings.)

FIG. 1. The W. B. Allen bucket base sprayer, in section; spring, *E*; rod, *D*; pinholes, *c*; valve-piston, *C*; packing, *F*; chamber, *A*; rose, *B*.

FIG. 2. The same, valve-piston with spiral spring, *E*; lettered and explained the same.

FIG. 3. The George Townsend knapsack agitator can, with hand-pipe, interior exposed: can, *A*; lid, *D*; shoulder loops, L^1, K^1; perforated dashers, *E*; valve, *N*; spring, *P*; guide, *R*; valve rods, *ms*; valve lever, *T*, with cord; fulcrum, *B*; discharge-pipe, *G*; hose, *H*; hand-pipe, *I*; nozzle, *K*.

FIG. 4. Same, section view; lettered and explained the same.

PLATE LVI.

KNAPSACK, HORSEBACK, AND PLOW SPRINKLERS.

(Adapted from patent drawings.)

FIG. 1. The W. T. Willie horseback sprinkler, side view; back rests, *A*; can rest, *C*; can, *B*; stopper, *O*; shut-off, *D*; nozzle, *d*.

FIG. 2. Same, top view; lettered and explained the same.

FIG. 3. Same, rear view; lettered and explained the same.

FIG. 4. The T. B. Taylor plow sprinkler, in section; plow, *ADGBF*; liquid cylinder, *H*; filling tube, *J*; cord, *L*; spray, *y*.

FIG. 5. The C. A. Ramsey knapsack sprinkler; receptacle, *A*; filler, *a*; hand-pipes, *B*, hung at *d*; nozzles, *b*.

FIG. 6. The F. M. Gray imported knapsack sprinkler, in operation.

PLATE LVII.

ROTARY SIEVE MACHINES, ETC.

(Adapted from patent drawings.)

FIG. 1. The W. T. Robinson combined sprinkler and rotary duster, top view; frame, *AT*; sprinkler, *aDEBF*; powder box, *T*; windlass, *N*; pulleys, *PQ*; belt, *O*; lever, *S*; shaft, *G*; rotary sifters, *H*.

FIG. 2. Same, section view; lettered and explained the same.

FIG. 3. The N. A. Davis rotary duster, to cart, rear view; cart, *A*; shaft, *yB*; spring, *b*; bearings, *cc*; pulley, *a*; rotary sifters, *E*.

FIG. 4. Same, sifters in section.

FIG. 5. The C. H. Levy rotary duster, front view; standards, *G*; crank fork, *F*; bolt, *H*; crank, *Ed*; shaft, *D*; rotary sifters, *A*.

FIG. 6. Same, in section; lettered and explained the same.

FIG. 7. Simple sifting can.

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PLATE LVIII.

DIVERS SIEVE MACHINES.

(Fig. 5 from Dept. Report on Cotton Insects, 1879; the rest adapted from patent drawings.)

FIG. 1. The F. A. Eldridge rotary brush sieve machine; frame, *CA*; wheels, *B*; belts, *h*; shaft, *g*; gears, *fe*; powder boxes, *D*; brushes, *d*.

FIG. 2. Same, side view; lettered and explained the same.

FIG. 3. Same, rear view; lettered and explained the same.

FIG. 4. The W. T. Willis sieve machine, section view; supporting bar, *C*; adjustment bar, *D*; standards, *B*; powder boxes, *A*; sieves, *p*.

FIG. 5. The J. S. Smith rotary brush sieve machine, in operation.

FIG. 6. The T. B. Taylor combined plow sprinkler and duster, in section; plow, *ABDFG*; sprinkler, *LHJ* (see Plate LVI); screen, *P*; rods, *S*; flanges, *E*; rotary sifter, *Q*.

FIG. 7. The J. W. Young shoulder support rotary sifter; support, *BFO*; mortices, *a*; suspender, *DE*; cylinder, *G*; adjuster, *K*; crank, *h*; same in section, *HGKi*; brush, *H*.

PLATE LIX.

SWEEPING MACHINES.

(From patent drawings.)

FIG. 1. The J. Helm sweeper and crusher, side view: crushing blocks, *eef*; wheel, *c*; frame, *FABbldn*; shaft, *D*; brushes, *E*.

FIG. 2. Same, crusher in section; lettered and explained the same.

FIG. 3. Same, showing other brushes, *F*; section view, lettered and explained the same.

FIG. 4. The W. Ewing sweeper and stifler, top view; tray and frame, *bc*; wheels, *de*; ratchet pins, *gh*; brushes, *m*.

FIG. 5. Same, side view; lettered and explained the same.

FIG. 6. The Wood-Smith tray sweeper, top view; frame, *tabb*; wheels, *c*; pan, *fm*; arms, *g*; bar, *b*; wings, *ee*; bearings, *d*; handle, *k*; pins, *l*; flappers, *oo*, hinged at *p*; ratchet, *s*; springs, *y*; crank lever, *r*; whiffletree, *a*.

FIG. 7. Same, in cross-section; lettered and explained the same.

FIG. 8. Same, longitudinal section; lettered and explained the same.

PLATE LX.

DIVERS MOTH TRAPS.

(Fig. 4, 5 original; Fig. 2 from Dept. Report on Cotton Insects, 1878.)

FIG. 1. The J. G. G. Garrett moth trap, earlier pattern; stake, *A*; board, *B*; pan, *c*; lantern, *E*; braces, *F*.

FIG. 2. The B. F. McQueen moth trap, in section; socket, *C*; pan, *B*; lantern, *A*; deflector, *D*.

FIG. 3. The J. N. Binkley moth trap.

FIG. 4. The J. E. Walker moth trap.

FIG. 5. A simple moth trap.

PLATE LXI.

DIVERS MOTH TRAPS (continued).

(Figs. 1, 3, 5, 6 original; Fig. 4, from patent drawing.)

FIG. 1. The net trap; net, *mn*; its open base, *z*, with weight; supports, *j*; lantern, *l*; standards, *s*; cleats, *c*, for bait board; flared inlet, *xx*; glass or bright deflector, *i*; side flange, *h*; roof flange, *r*; ridge fold, *v*; W. S. Barnard, inv.

FIG. 2. The J. G. G. Garrett improved moth trap, in section; stake, *s*; tray, *t*; liquid bait, *x*; flanges, *e*; roof, *r*; light, *i*.

FIG. 3. The J. Stith "Cotton-worm Exterminator" trap; tray, *d*; opal glass lantern, *a*; side-flange, *b*; cover-flange, *c*.

FIG. 4. The J. M. Heard moth trap, in section; tray and liquid, *AB*; flange, *e*; standard, *eE*; cone-deflector, *e*; roof-flange, *dD*.

FIG. 5. The E. D. Pugh moth trap, the interior exposed: tray, *A*; lantern, *B*; light, *D*; vial, *E*; pegs, *ab*.

FIG. 6. The A. Le Blanc "Cotton Moth Destroyer;" wheels, *A*; platform, *B*; standards, *cd*; roof, *D*; suspended globe deflector, *E*; chandelier, *abF*.

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PLATE LXII.

MOTHS MISTAKEN FOR ALETIA.

(Original.)

FIG. 1. *Platyhypena scabra.* (Original.)
FIG. 2. *Laphygma frugiperda:* *a*, normal form; *b*, *c*, variations. (After Riley.)
FIG. 3. *Phoberia atomaris.* (Original.)
FIG. 4. *Aspila virescens.* (Original.)
FIG. 5. *Drasteria erechtea:* *a*, egg (greatly enlarged); *b*, *b*, full grown larva; *c*, cocoon; *d*, pupa; *e*, *f*, adult;—natural size. (Original.)

PLATE LXIII.

SPIDERS WHICH DESTROY ALETIA.

(Original.)

FIG. 1. *Epeira stellata:* *a*, male; *b*, female; *c*, male palpus; *d*, vulva;—enlarged.
FIG. 2. *Argiope fasciata:* *a*, male; *b*, female;—natural size; *c*, male palpus; *d*, vulva;—enlarged.
FIG. 3. *Theridula sphærula:* *a*, female, enlarged; *b*, natural size.
FIG. 4. *Linyphia communis:* *a*, male; *b*, female; *c*, male palpus; *d*, vulva;—all enlarged.

PLATE LXIV.

SPIDERS WHICH DESTROY ALETIA (continued).

(Original.)

FIG. 1. *Tetragnatha extensa:* *a*, male; *b*, female; *c*, *c'*, male palpus; *d*, vulva;—all enlarged.
FIG. 2. *Oxyopes viridans:* *a*, male; *b*, female;—natural size; *c*, male palpus; *d*, vulva;—enlarged.

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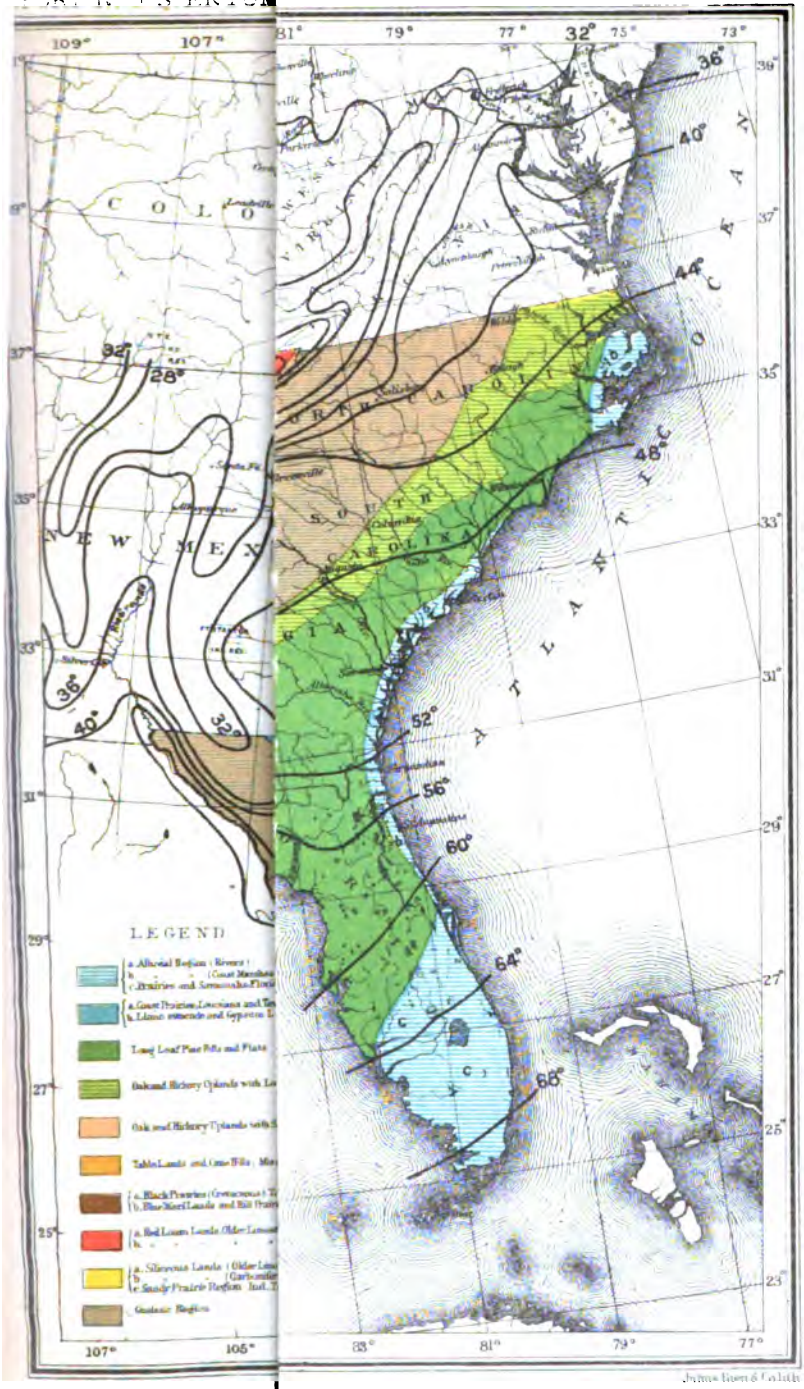

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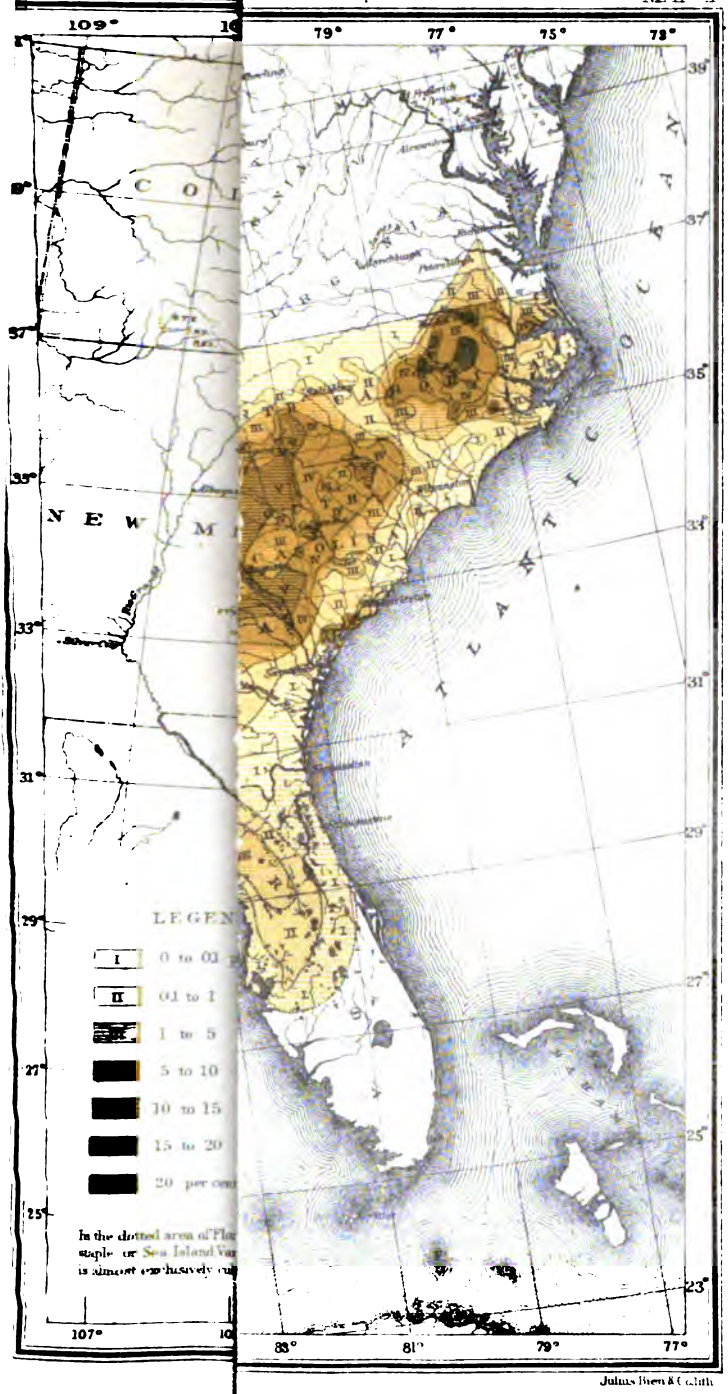

Julius Bien & Co. lith

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C.V. Riley, del. et pinx.

THE COTTON WORM.

(Aletia argillacea.)

A. Hoen & Co. Lith. Steam Baltimore

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ANOMIS ERECTA (Fabricius)

ANOMIS EXACTA (Walker)

ALETIA ARGILLACEA (Hübner)

Drawn under direction of C. V. Riley. A. Bloem & Co. Lithocaustic, Baltimore

ILLUSTRATIONS OF ANOMIS AND ALETIA.

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C.V.Riley, del. et pinx. Albert & Co. Lithocaustic, Baltimore.

THE BOLL WORM.

(Heliothis armigera.)

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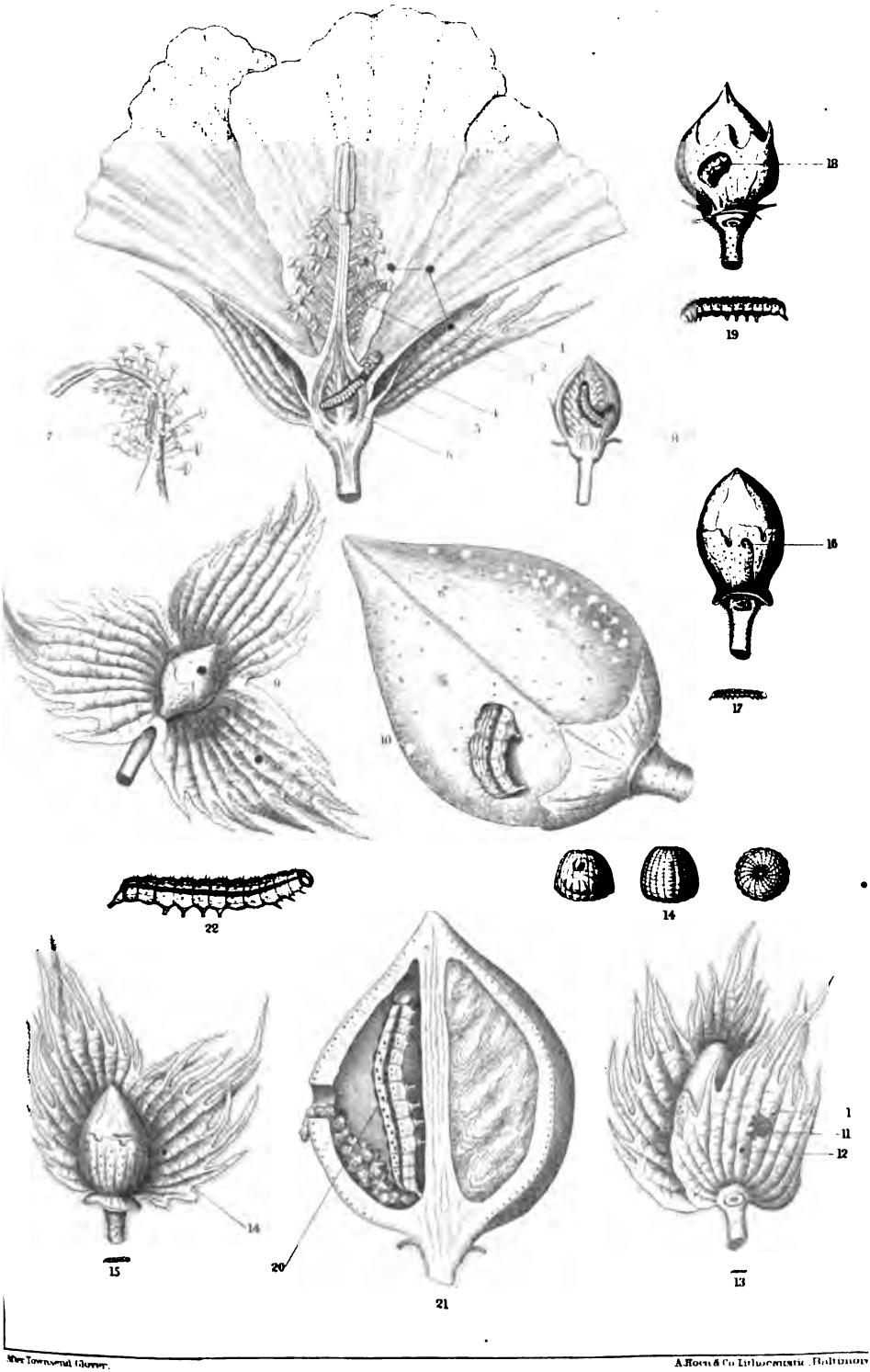

Mrs Townsend Glover. A. Hoen & Co Lithographers, Baltimore

THE BOLL WORM.

(Heliothis armigera.)

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THE ARMY WORM.

(Leucania unipuncta.)

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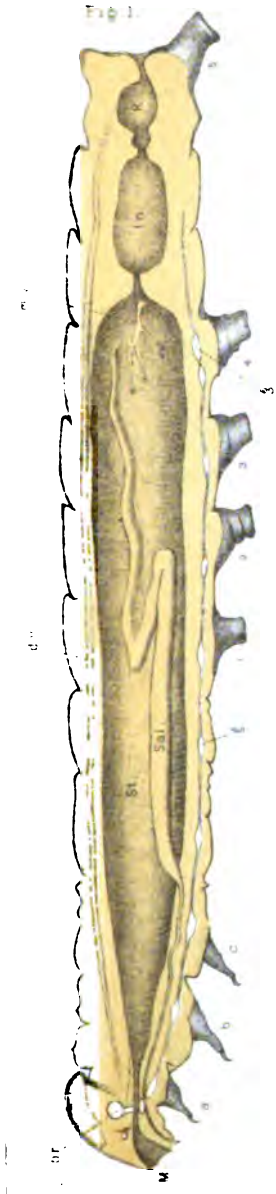

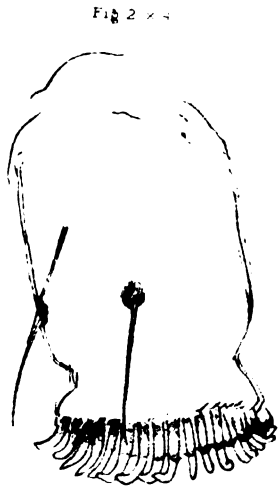

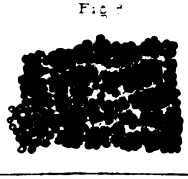

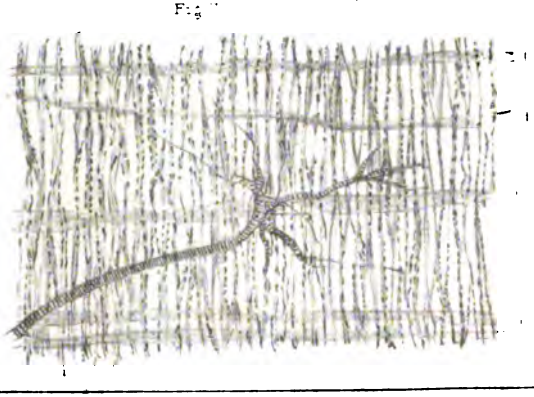

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ANATOMY OF ALETIA

Larva

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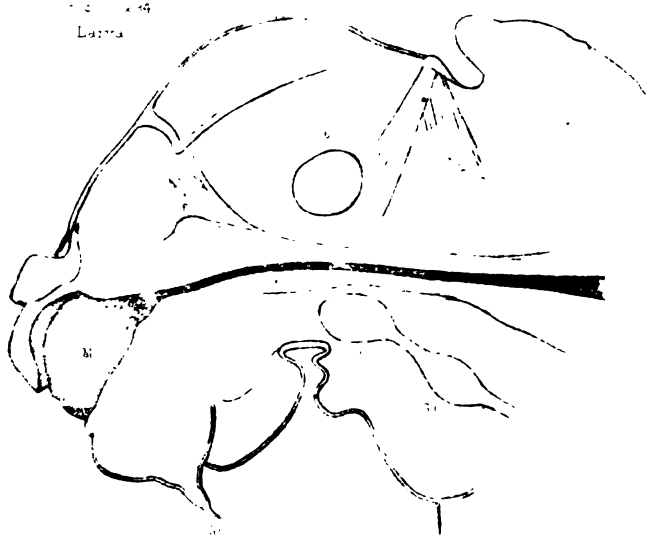

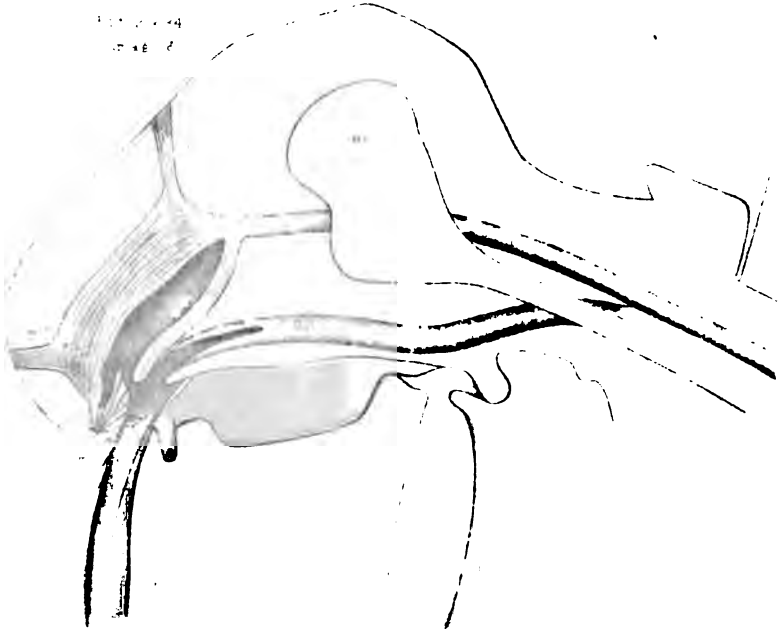

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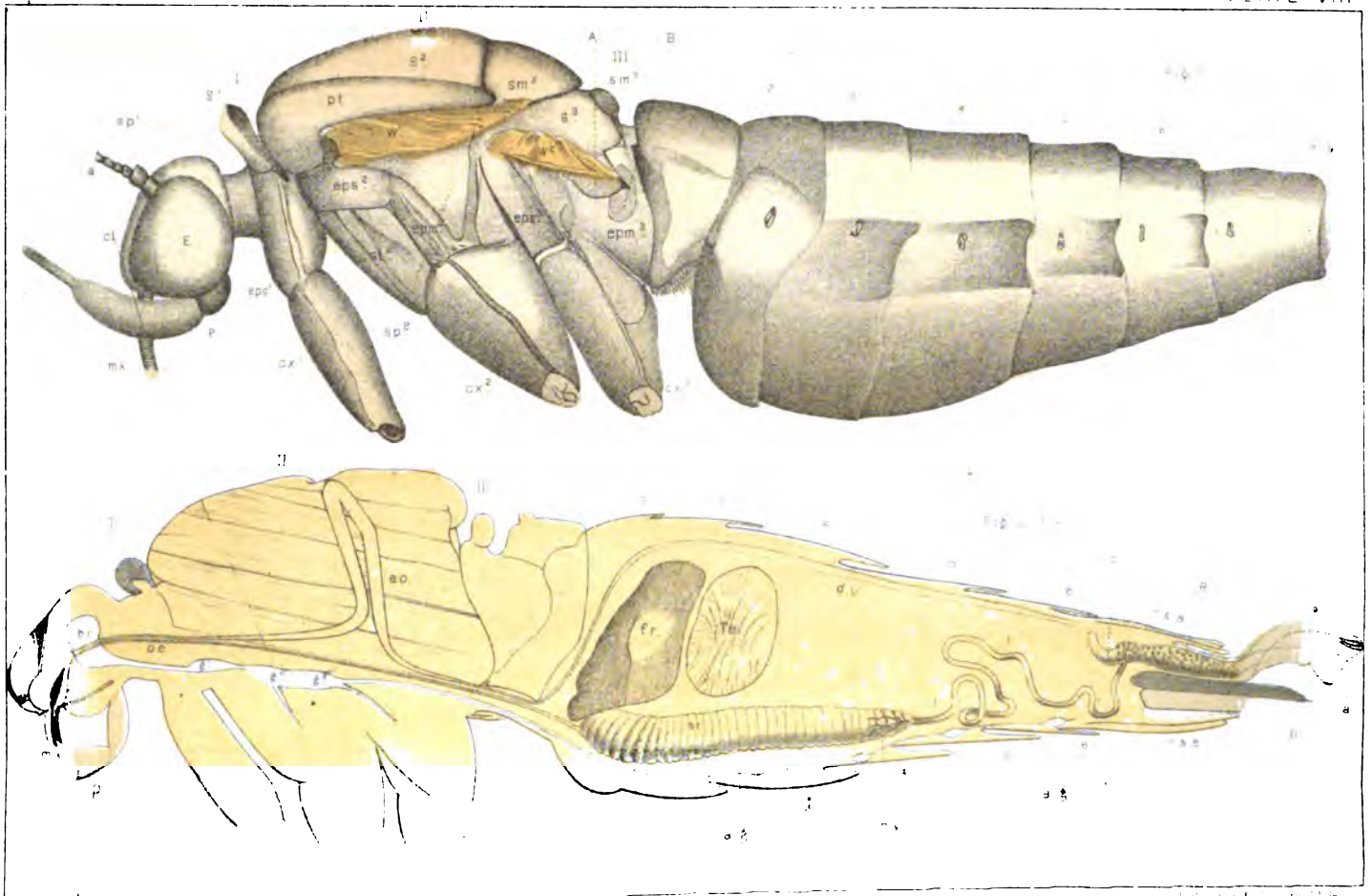

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ANATOMY OF ALETIA

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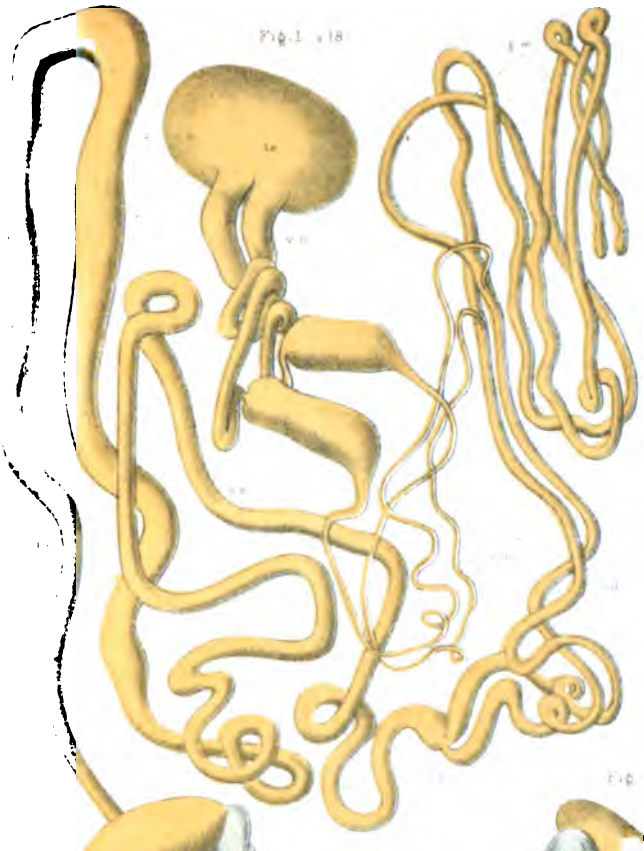


Fig. 3 × 16

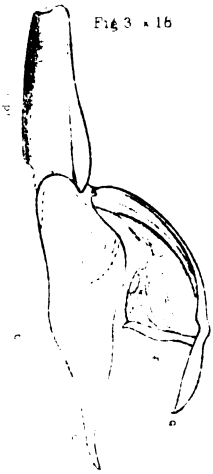
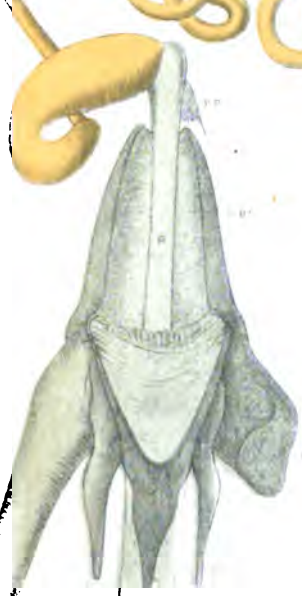


Fig. 4 × 50



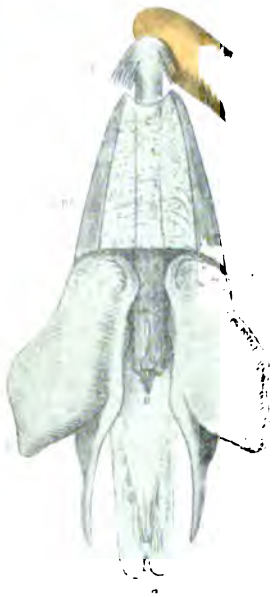


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Fig. 1 x 17

Fig. 2 x about 600

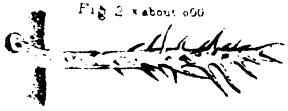


Fig. 3 x 34

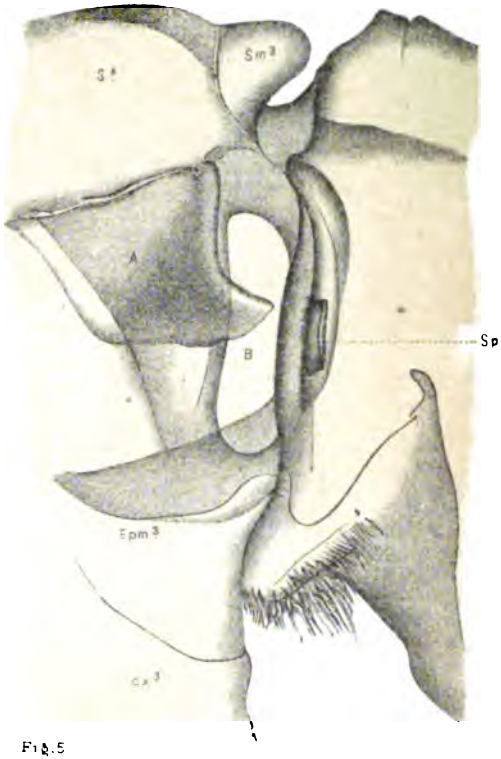


Fig. 4 x 172

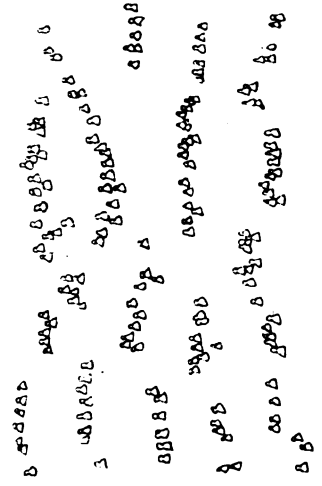


Fig. 5

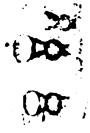


Fig. 6 x 420

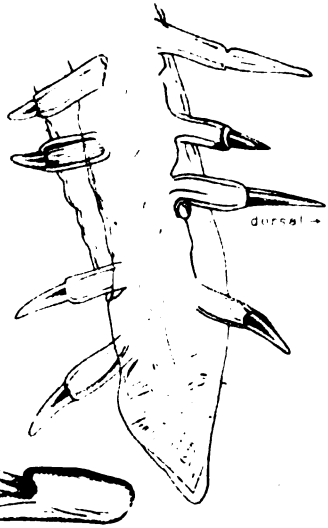


Fig. 7 x 420

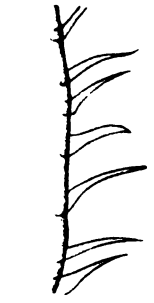
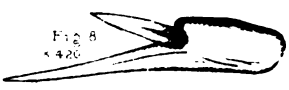


Fig. 8 x 420



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PYRETHRUM ROSEUM.

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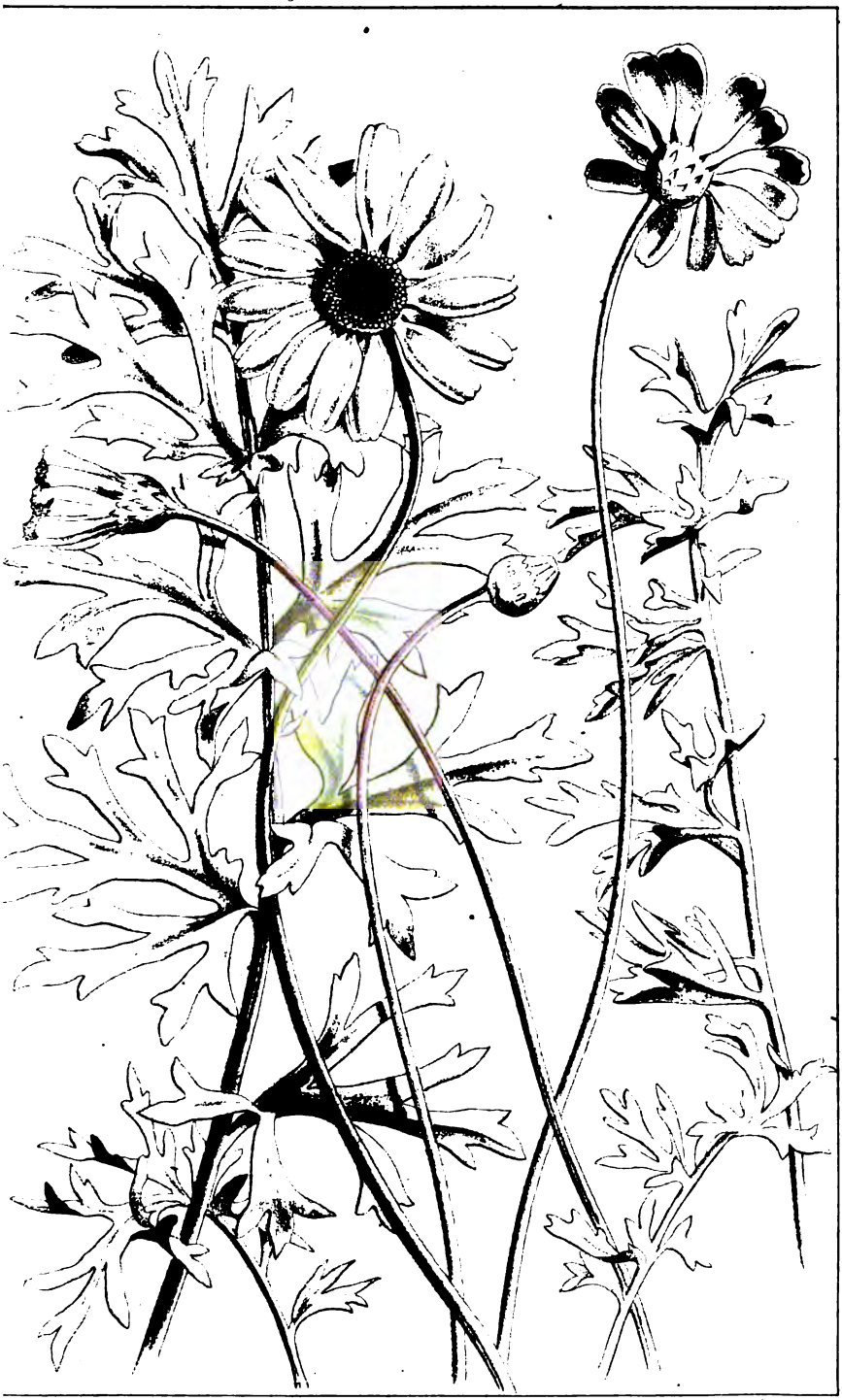

Painted from plants grown by C V. Riley. A. Hoen & Co. Lithocaustic. Baltimore.

PYRETHRUM CINERARIÆFOLIUM.

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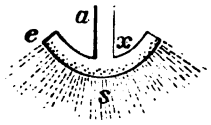


Fig. 6.

Fig. 7.

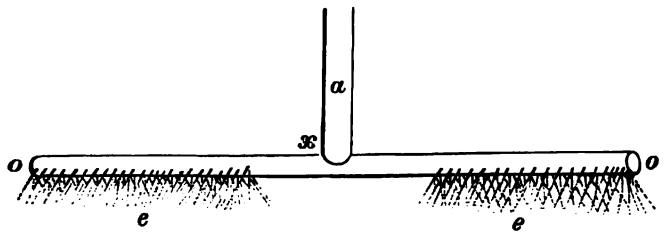


Fig. 5.

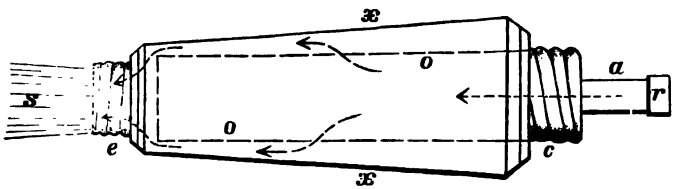


Fig. 8.

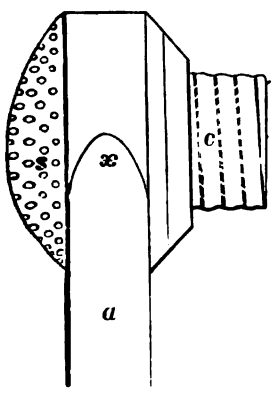
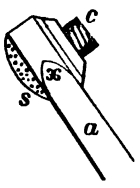


Fig. 3.



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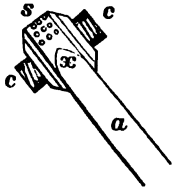

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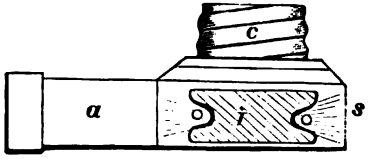

Fig. 2.

W. S. B., Del.

MANY-PUNCTURED SPRAY-NOZZLES.

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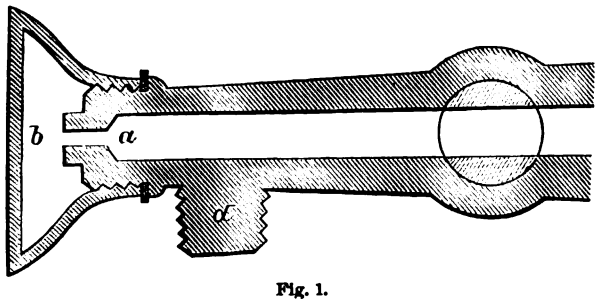

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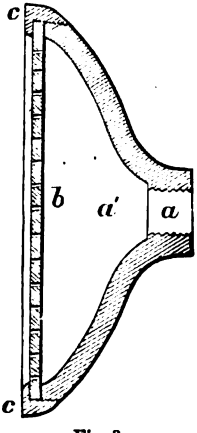

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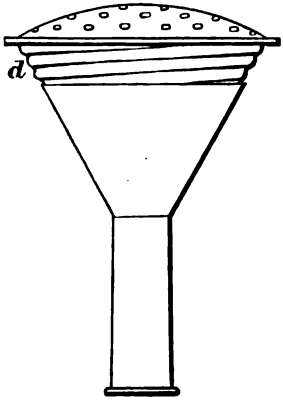

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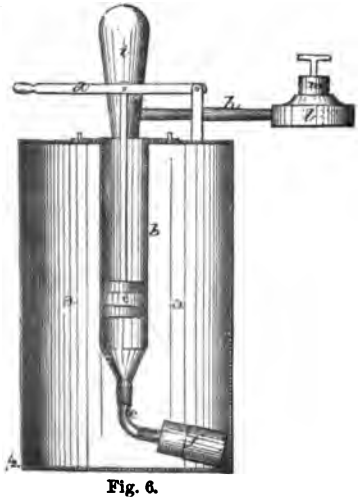

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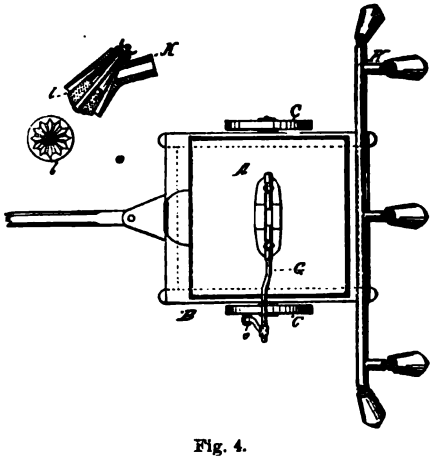

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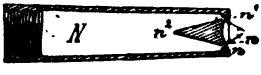

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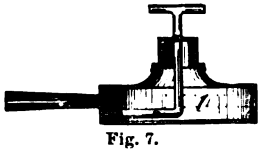

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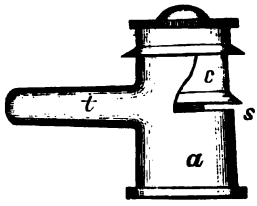

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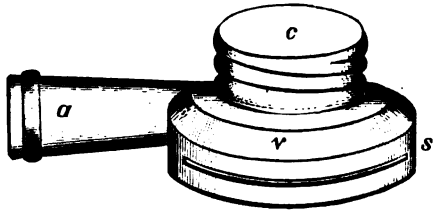

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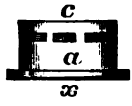

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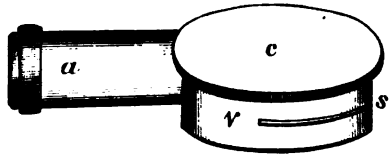

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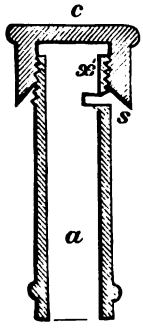

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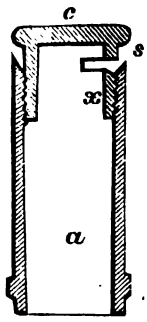

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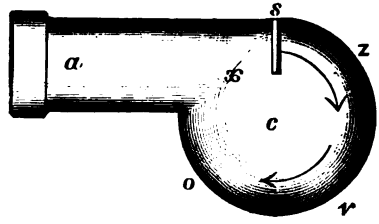

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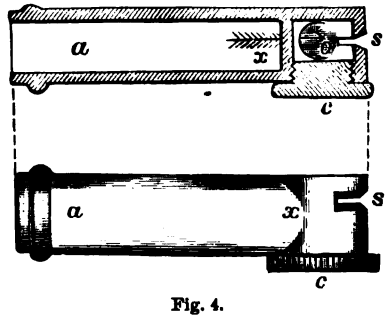

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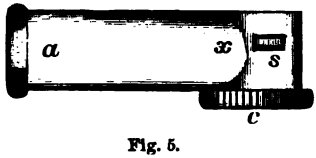

Fig. 5.

W. S. B., Del.

SLOT-NOZZLES FOR SPRAYING.

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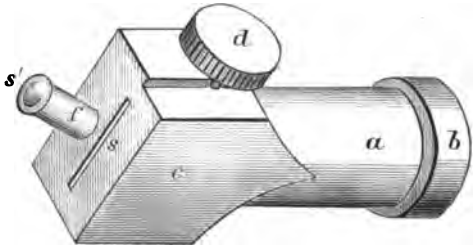

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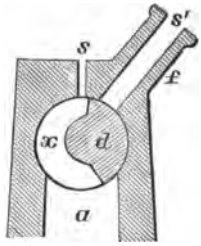

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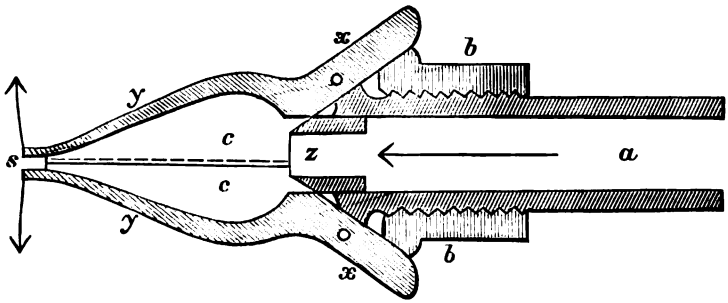

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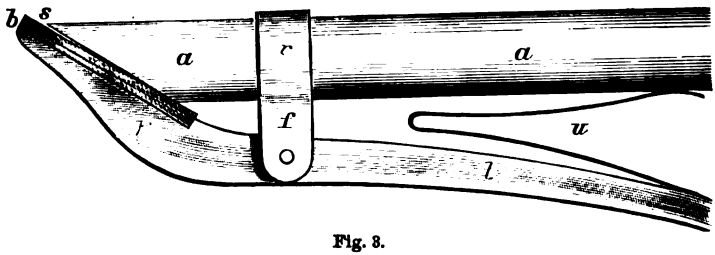

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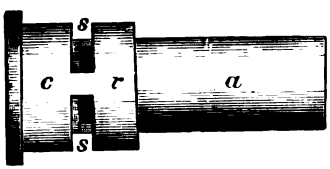

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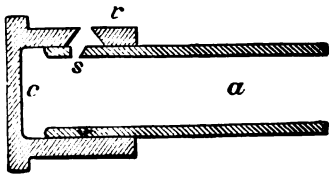

Fig. 2.

W. S. B., Del.

SLOT-NOZZLES FOR SPRAYING—Continued.

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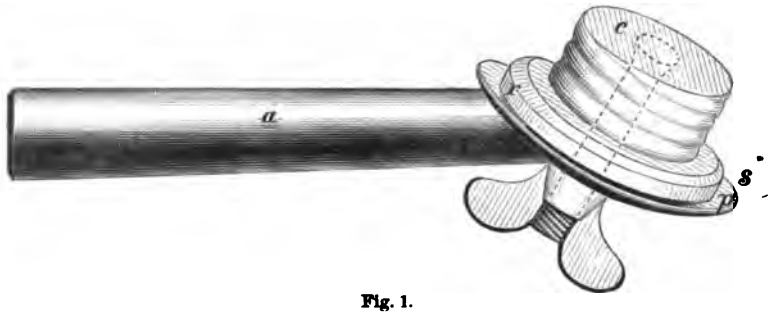

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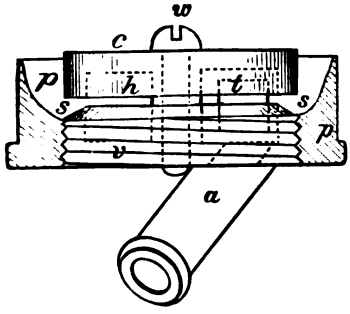

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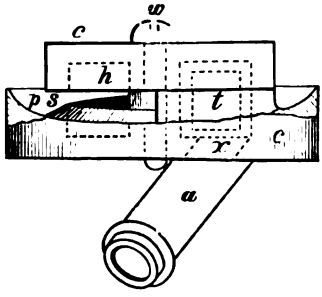

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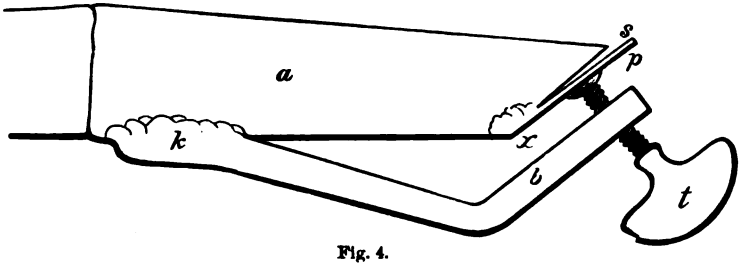

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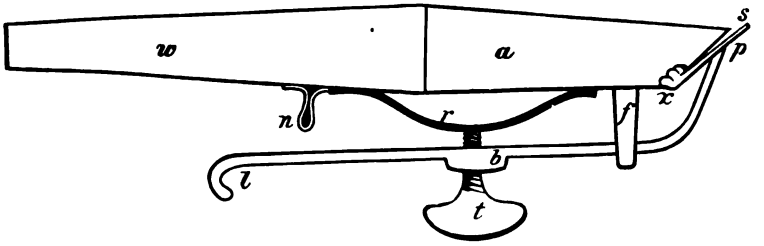

Fig. 5.

W. S. B., Del.

SLOT-NOZZLES FOR SPRAYING—Continued.

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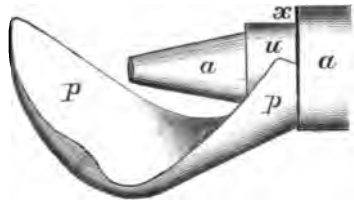

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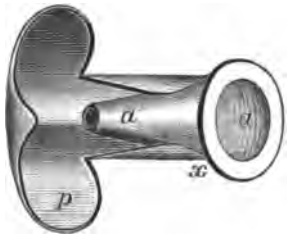

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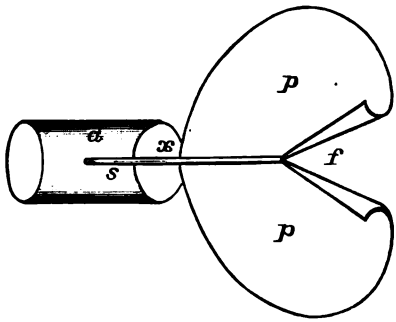

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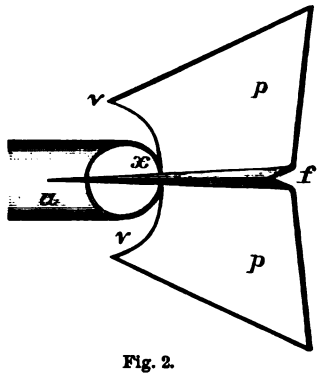

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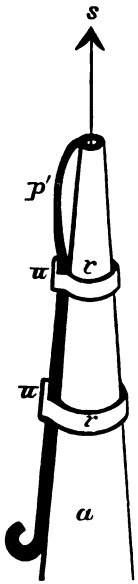

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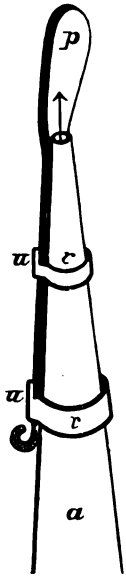

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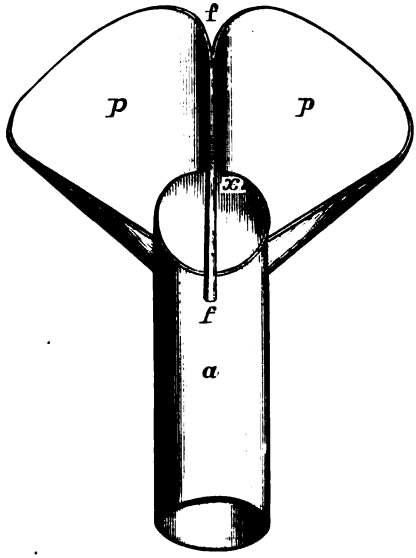

Fig. 1.

W. S. B., Del.

DEFLECTOR SPRAY-NOZZLES.

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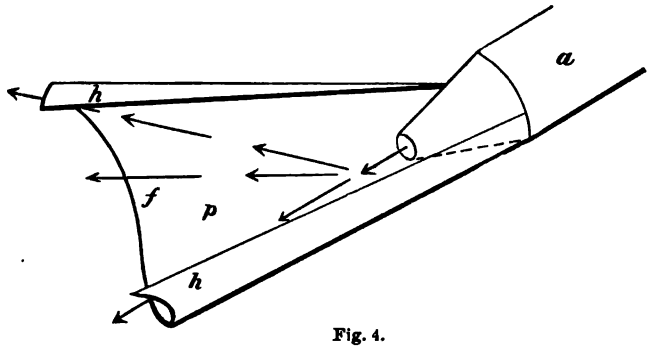

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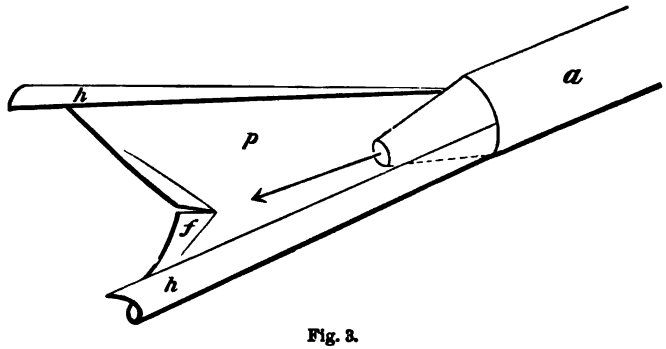

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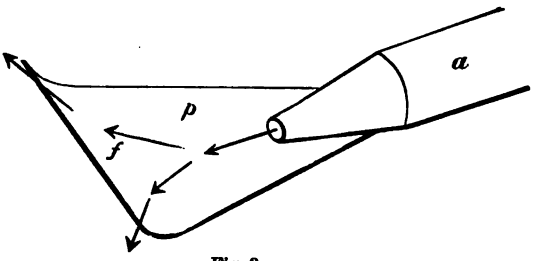

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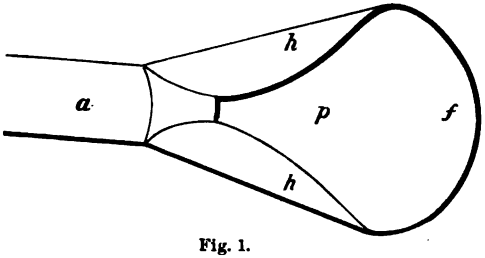

Fig. 1.

W. S. B., Del.

SIMPLE PATTERN SPRAY-DEFLECTORS.

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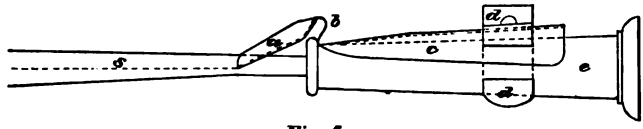

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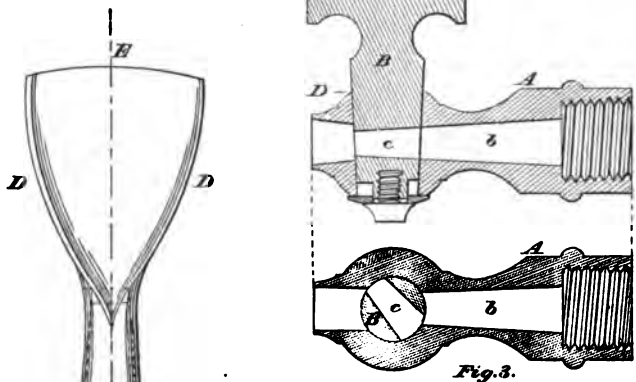

Fig. 4.

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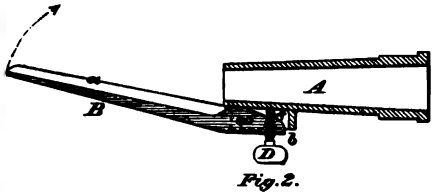

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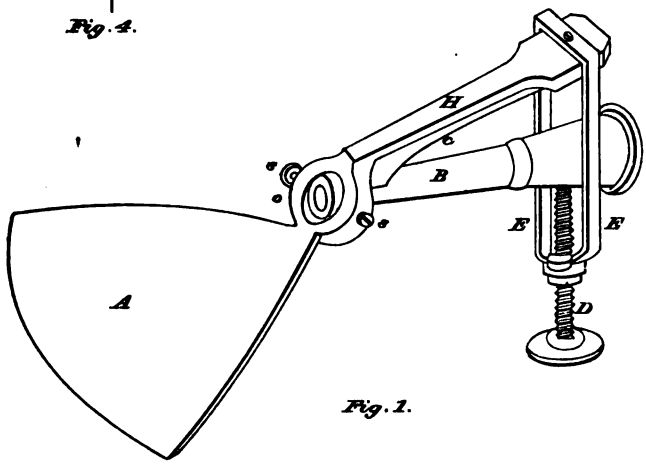

Fig. 1.

DEFLECTOR-NOZZLES WITH SOLID JET.

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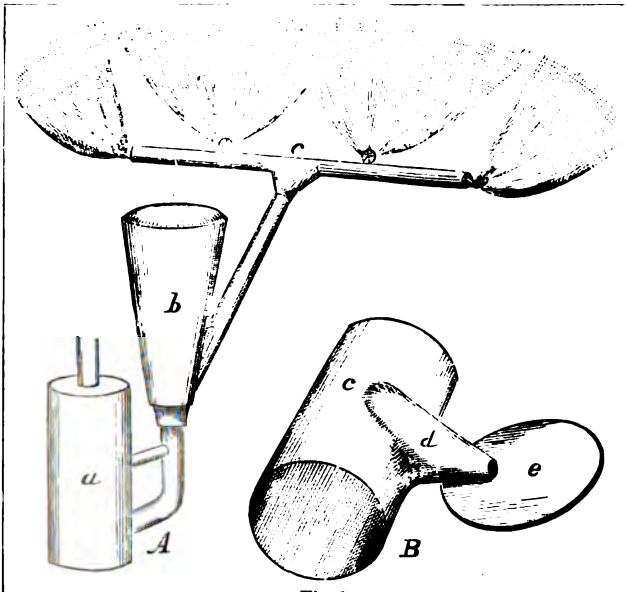

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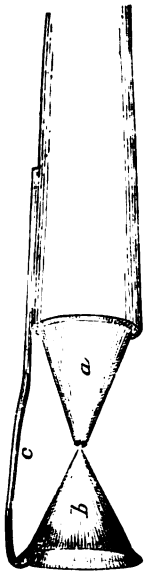

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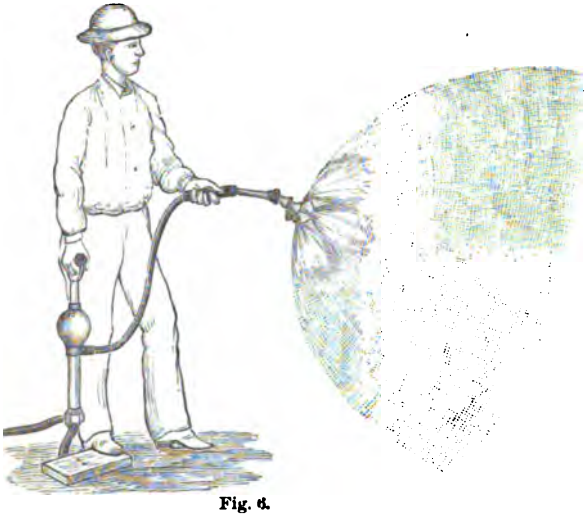

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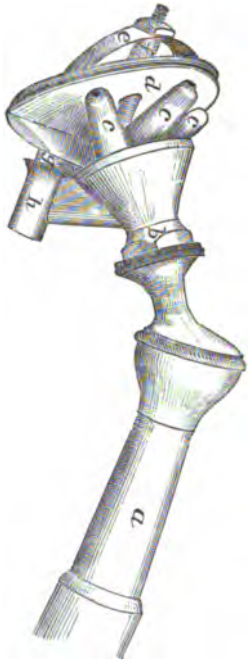

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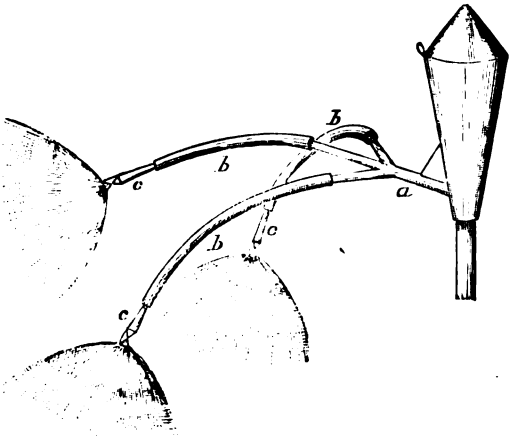

Fig. 3.

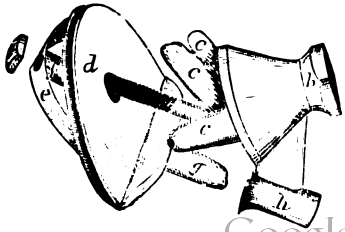

Fig. 5.

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TEXAS DEFLECTOR-NOZZLES.

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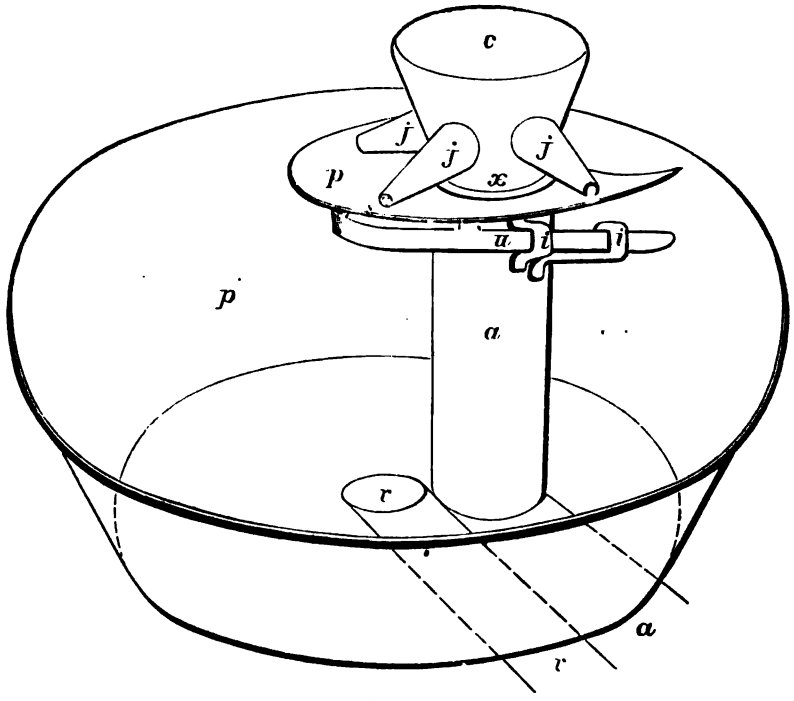

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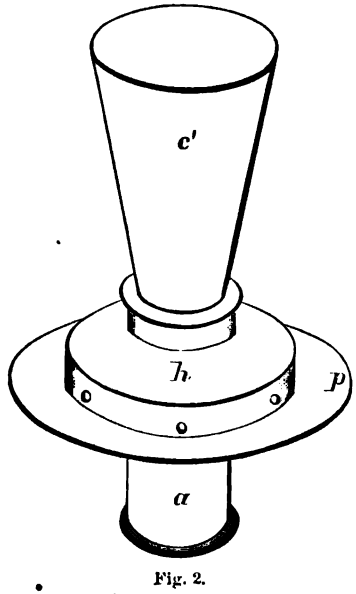

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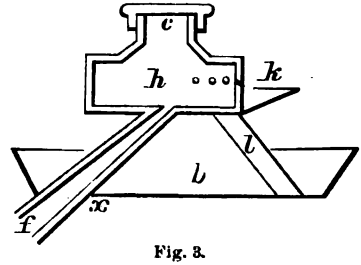

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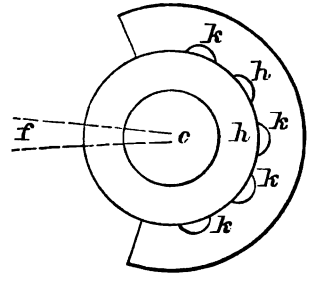

Fig. 4.

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DEFLECTOR-NOZZLES—Continued.

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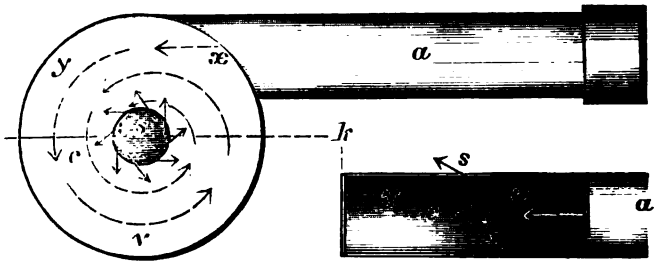

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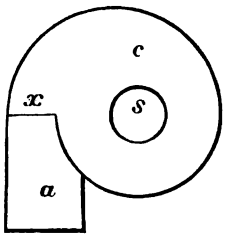

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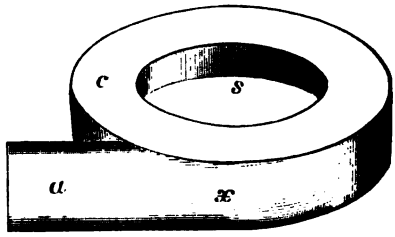

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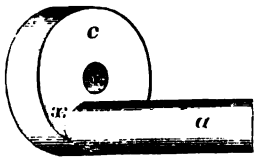

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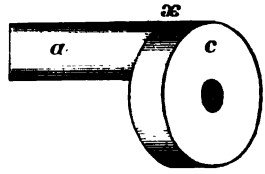

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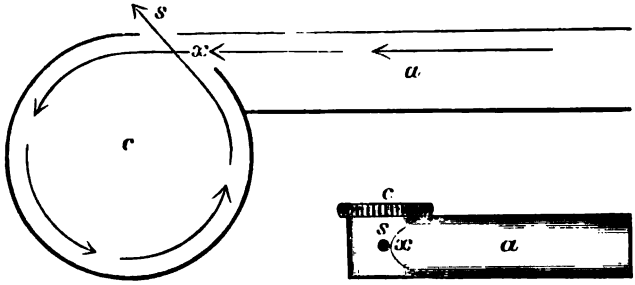

Fig. 6.

Fig. 7.

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EDDY-CHAMBER SPRAY-NOZZLES.

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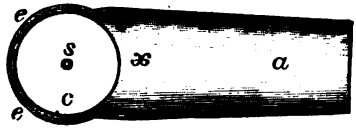

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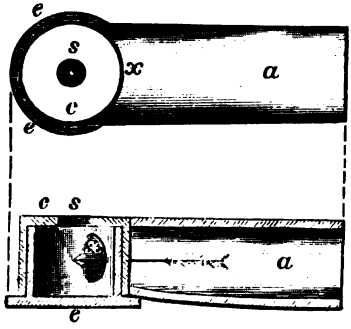

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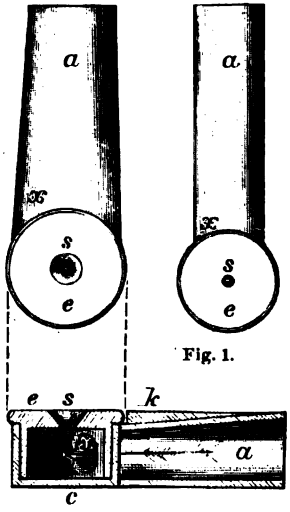
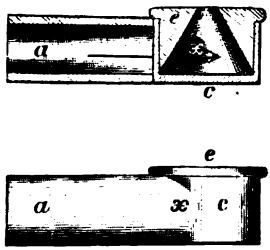


Fig. 1.

Fig. 3.

Fig. 5.



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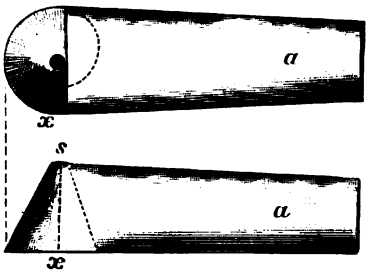

Fig. 7.

W. S. B., Del.

EDDY-CHAMBER SPRAY-NOZZLES—Continued.

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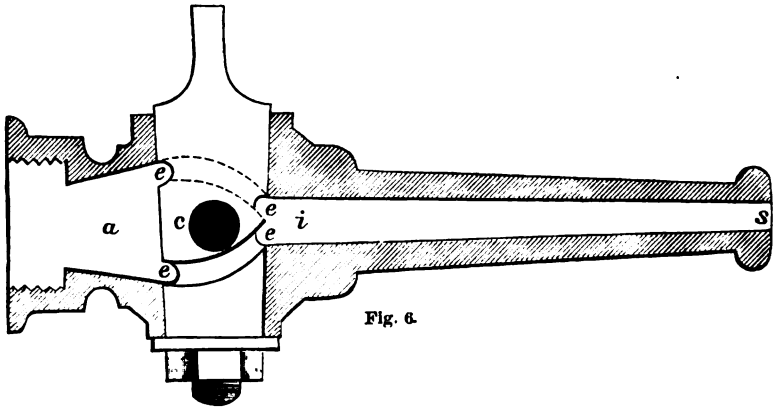

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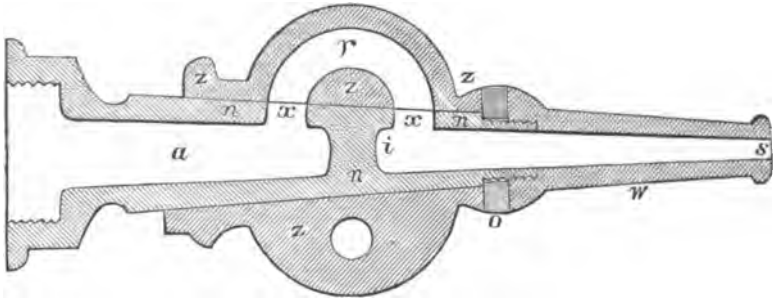

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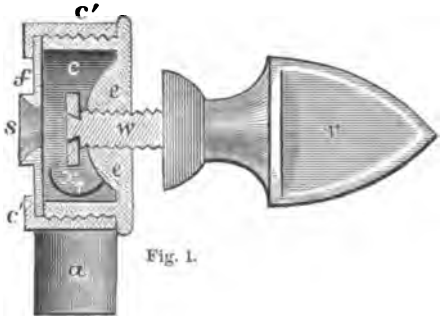

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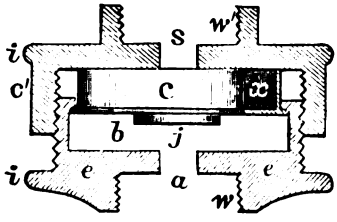

Fig. 2.

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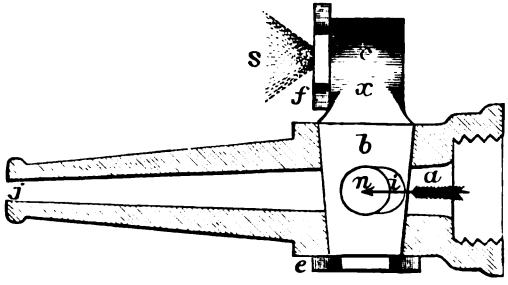

Fig. 3.

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EDDY-CHAMBER AND BARREL-SPRAYERS.

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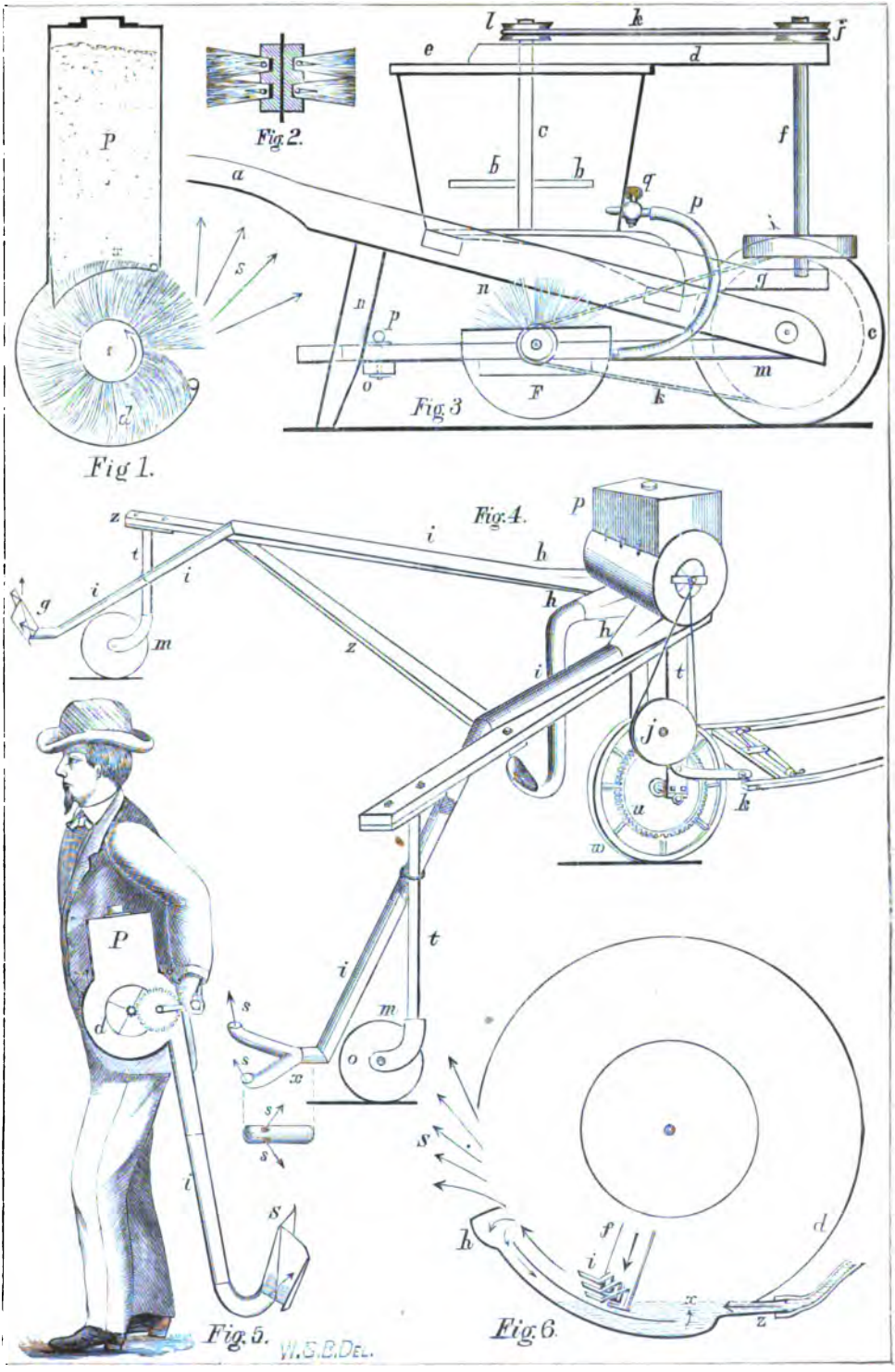

RORARY THROWERS AND BLOWERS OF POISON

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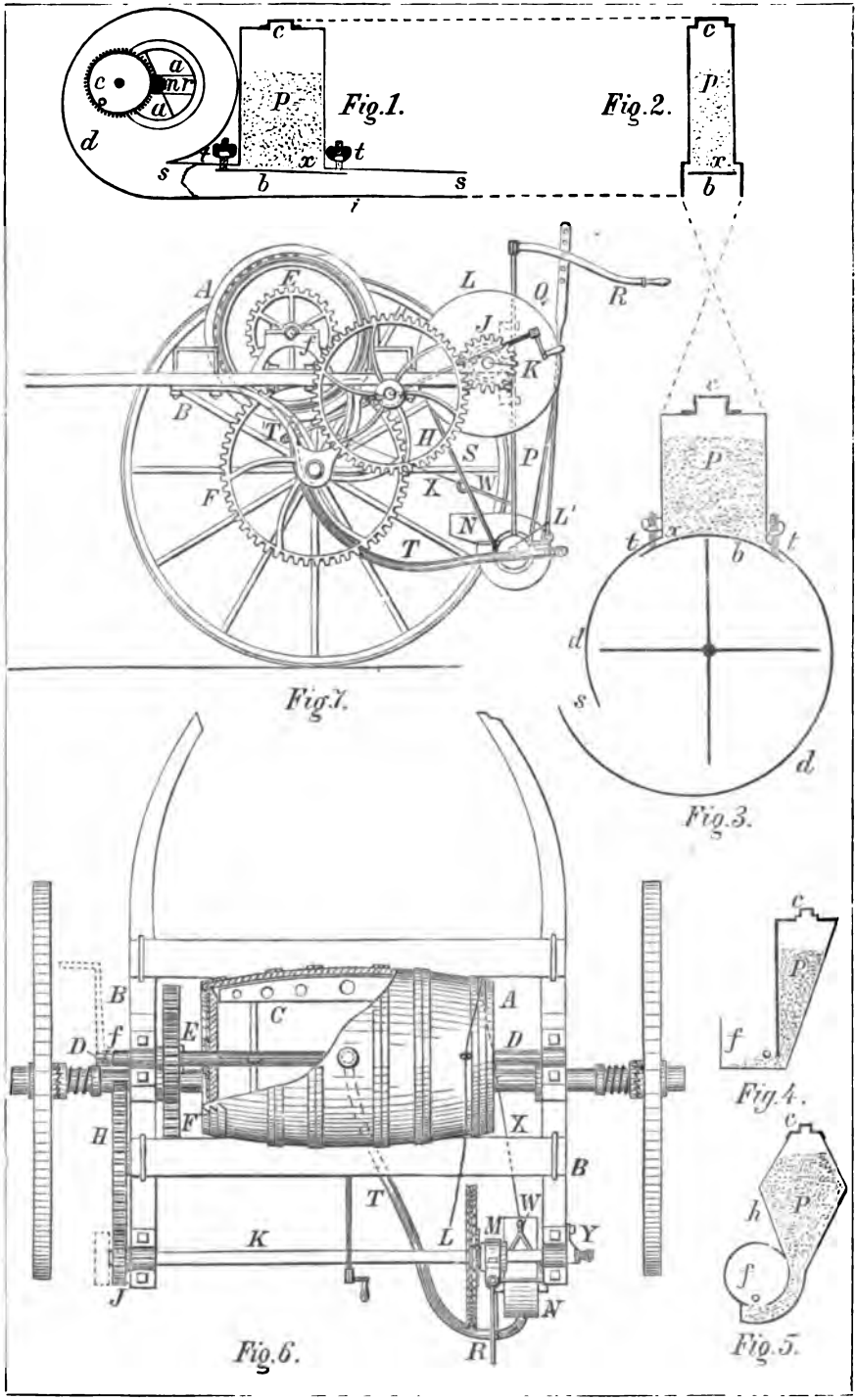

ROTARY BLOWERS OF POISON.

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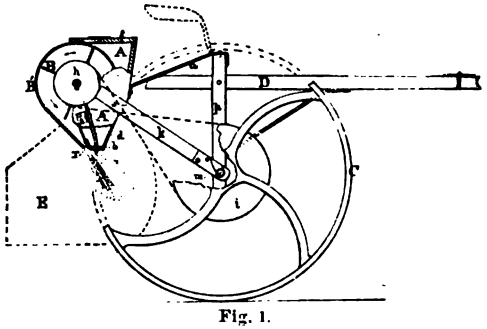

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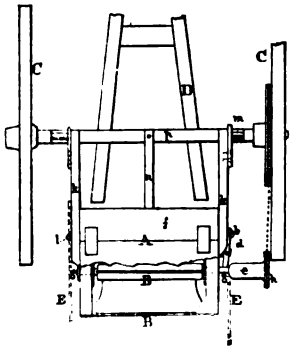

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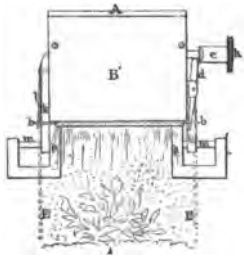

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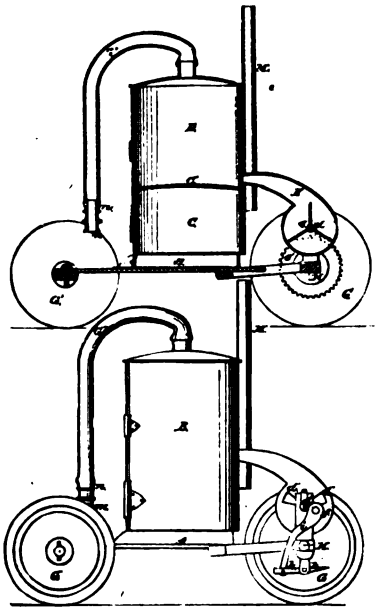

Fig. 4.

ROTARY BLOWERS OF POISON—Continued.

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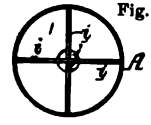
Fig. 4.



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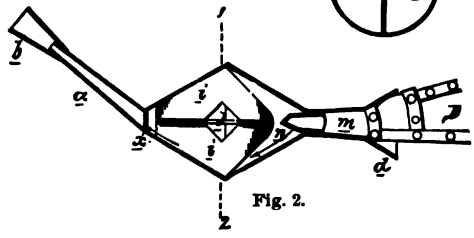

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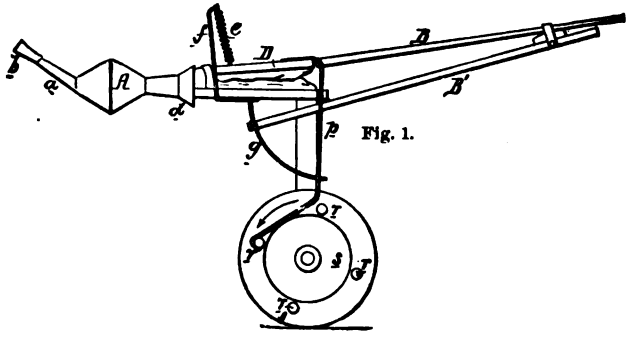

Fig. 1.

BELLOWS-BLOWERS OF POISON.

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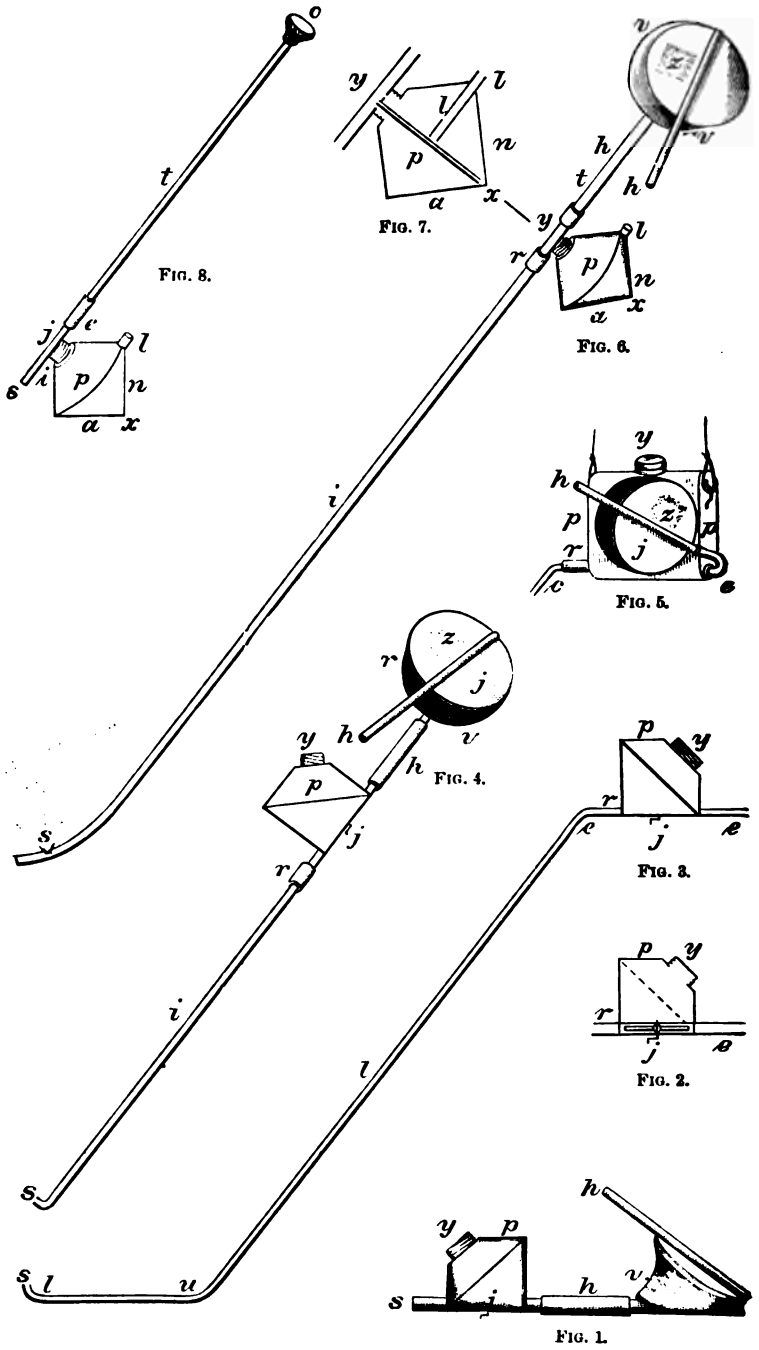

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SIMPLE BELLOWS-BLOWERS OF POISON.

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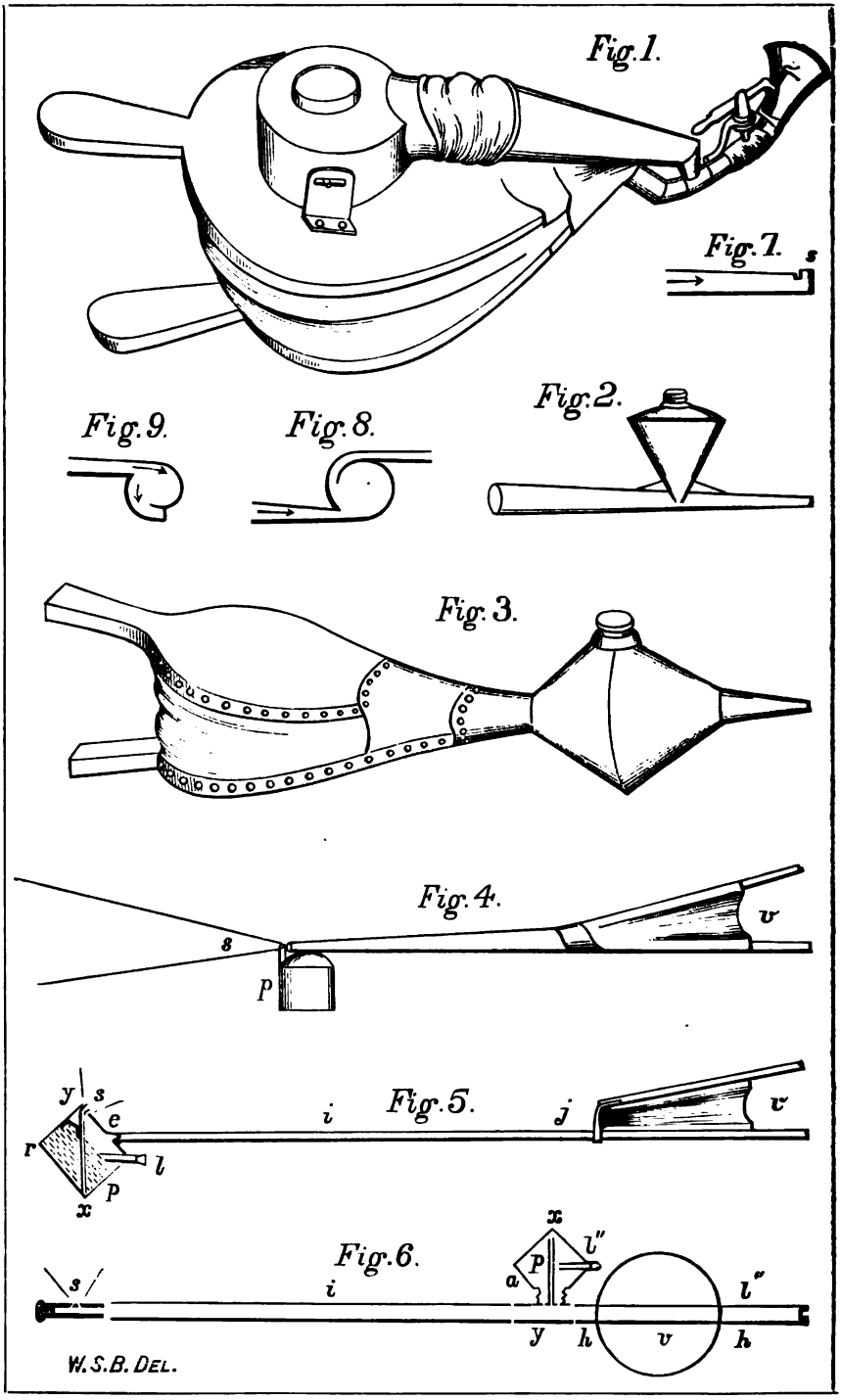

SIMPLE BELLOWS-BLOWERS OF POISON.

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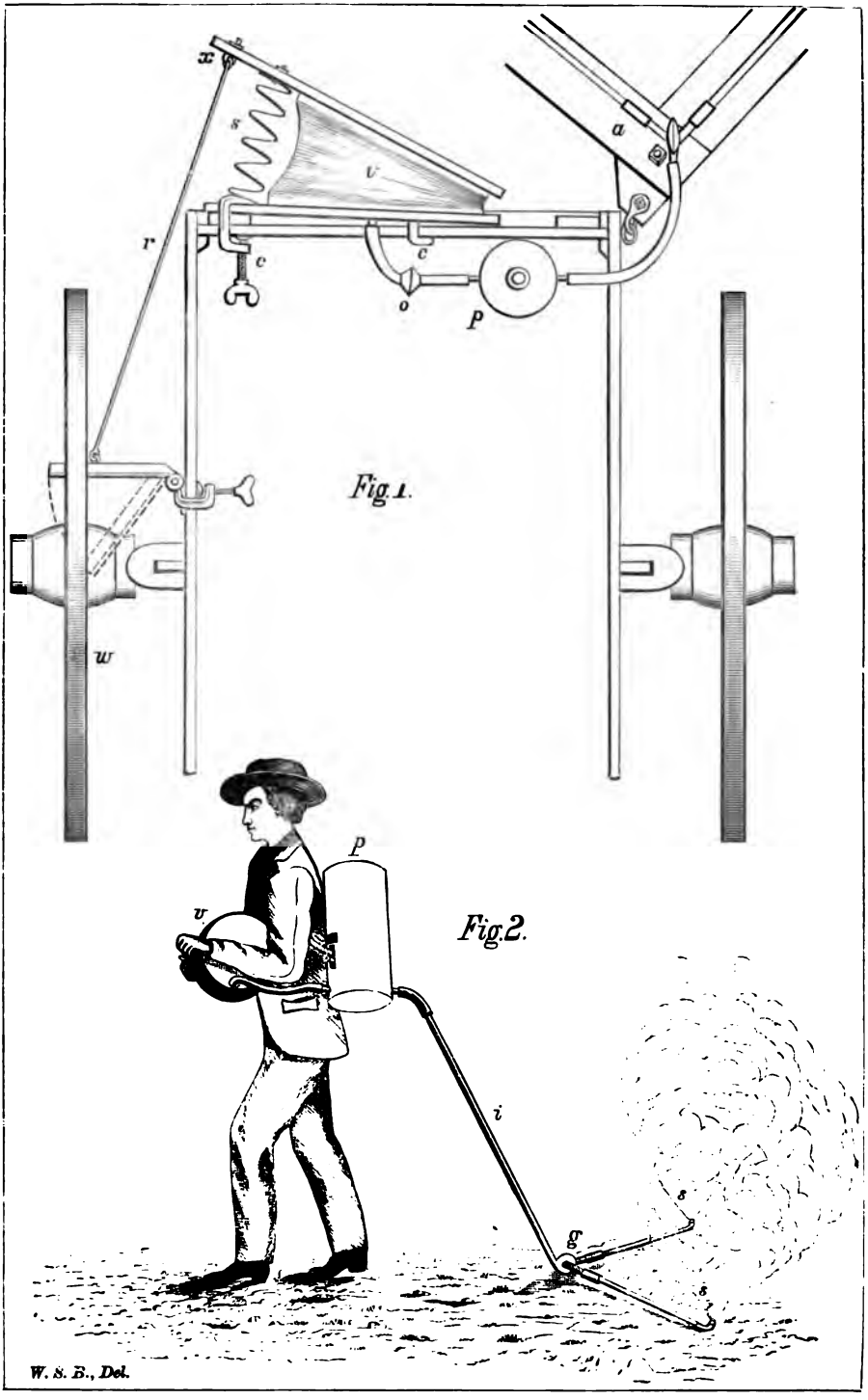

COMPOUND BELLOWS-POISONERS

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PLOW BELLOWS-POISONER.

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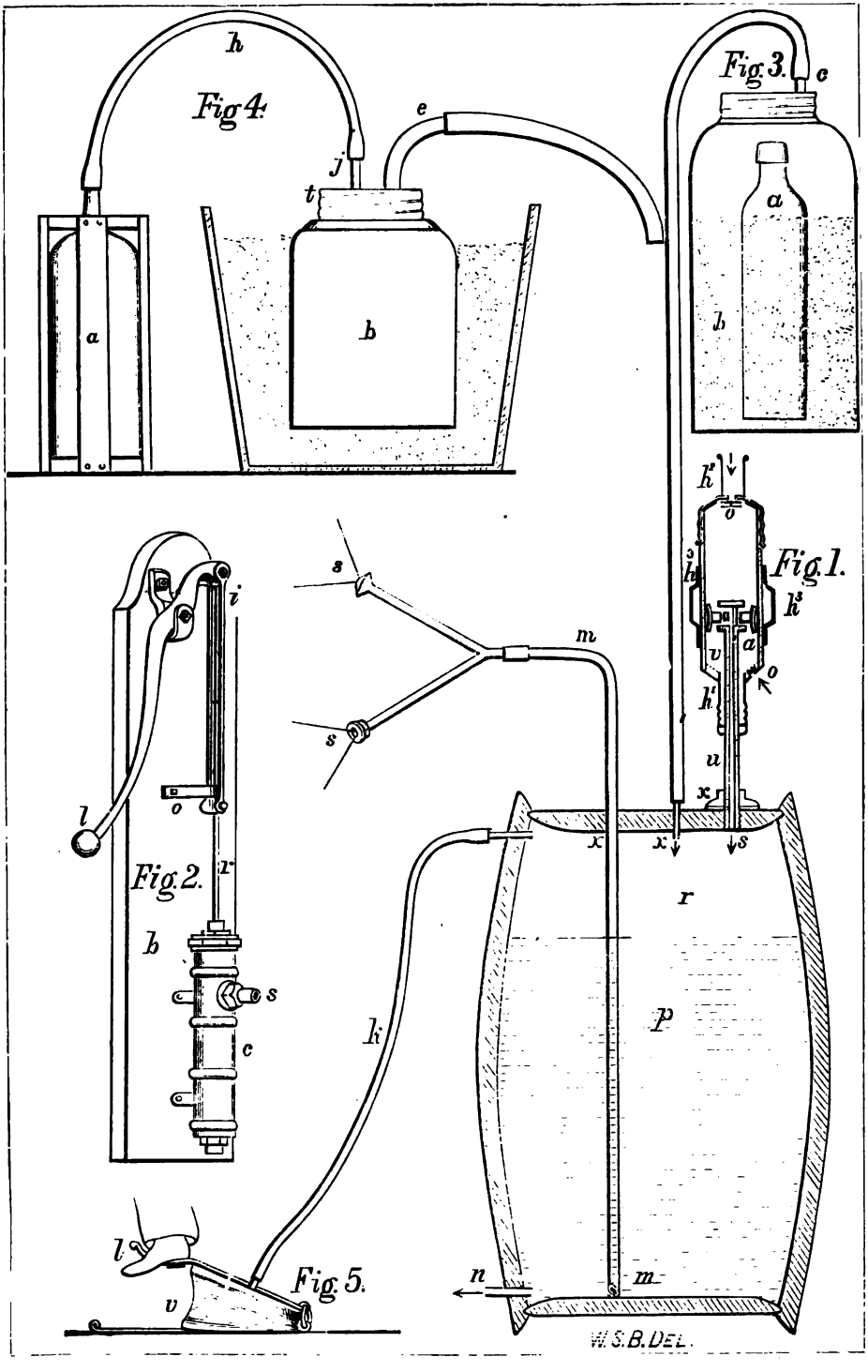

PNEUMATIC-PRESSURE SPRAYERS.

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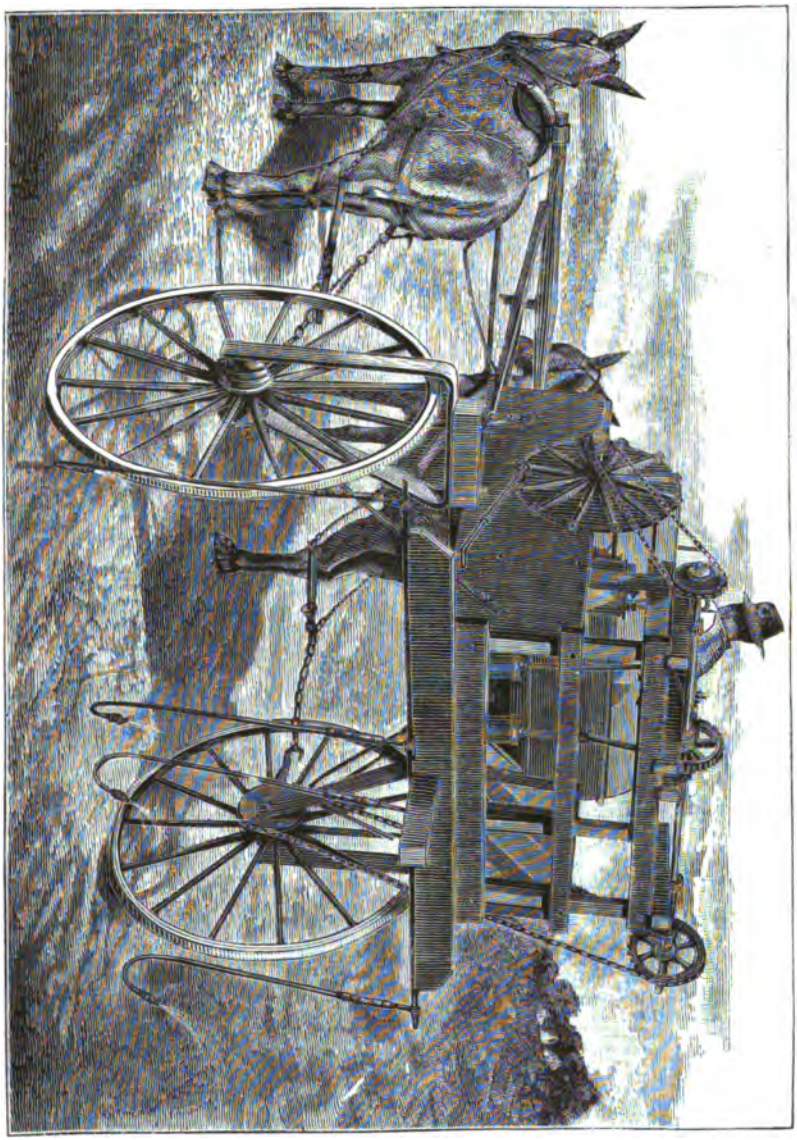

THE W. J. DAUGHTREY AUTOMATIC ATOMIZER.

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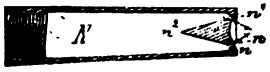

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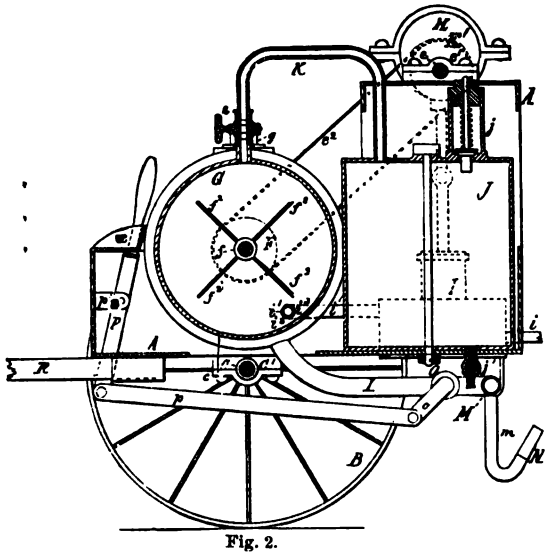

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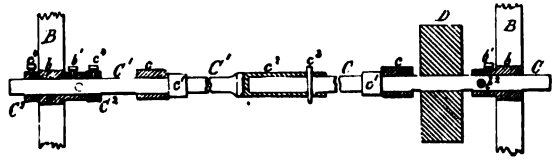

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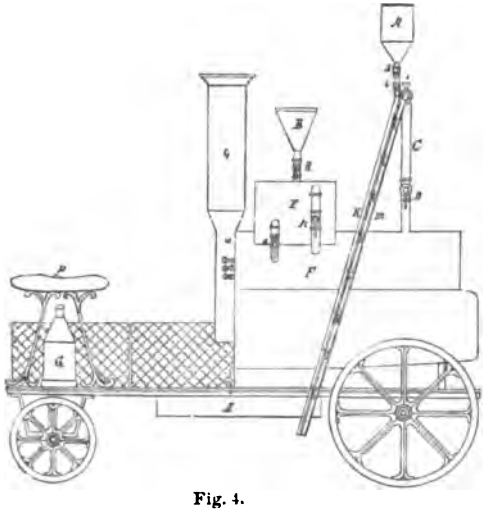

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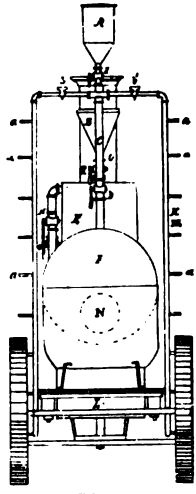

Fig. 5.

THE W. J. DAUGHTREY AUTOMATIC ATOMIZER (continued) AND THE C. STEINMANN VAPORIZER.

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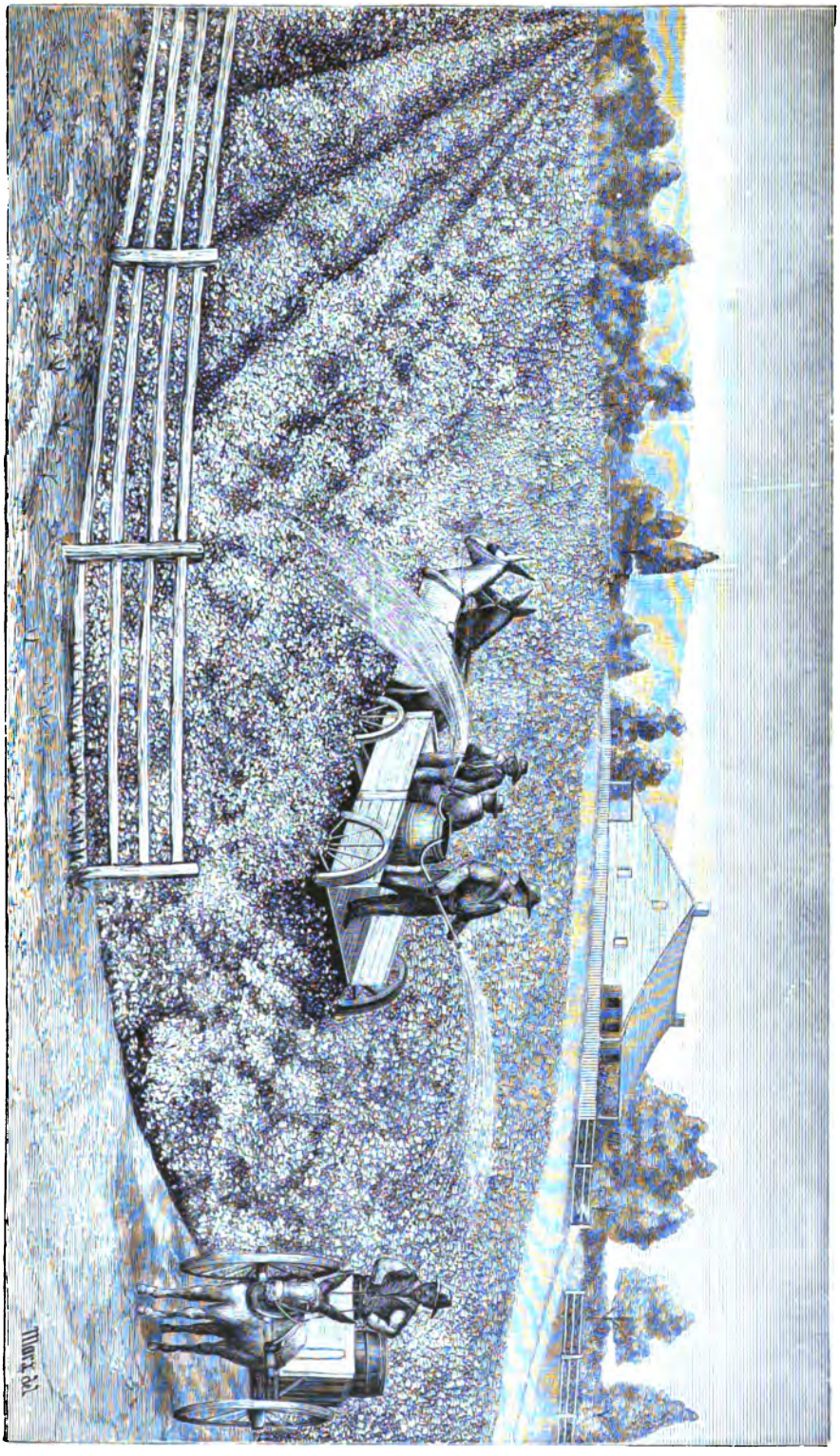

METHOD OF POISONING WITH HYDRONETTES.

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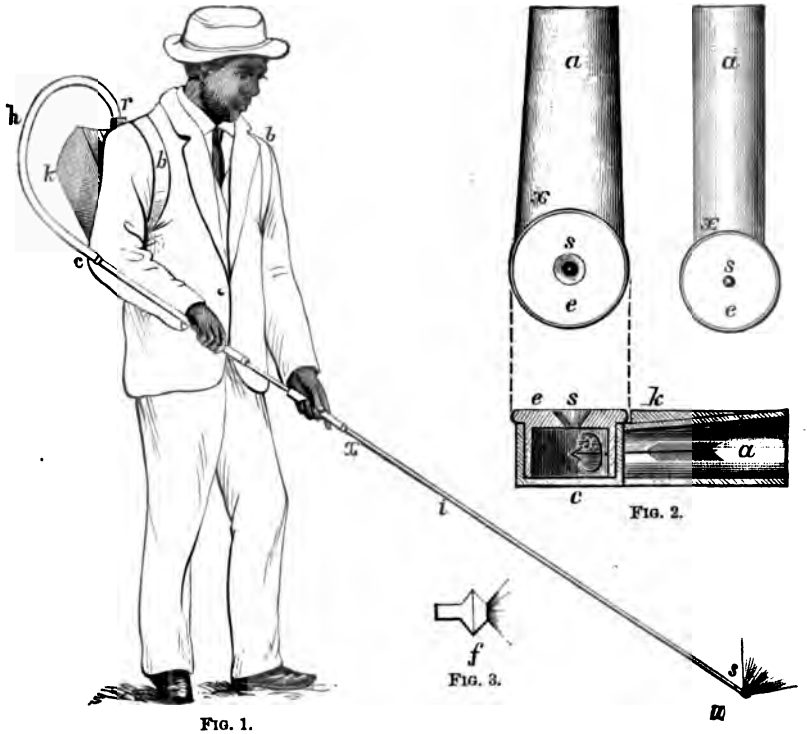
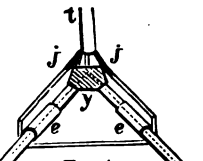


FIG. 1.

FIG. 2.

FIG. 3.



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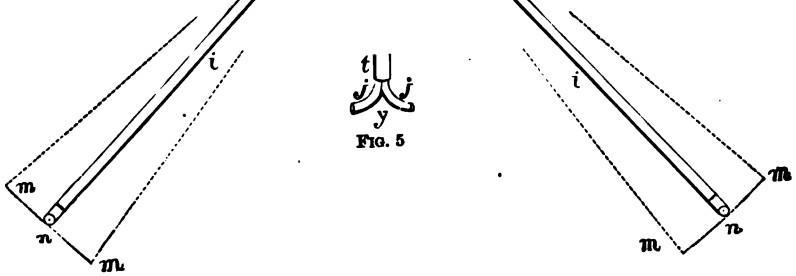

FIG. 5

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SIMPLE NETHER SPRAYERS.

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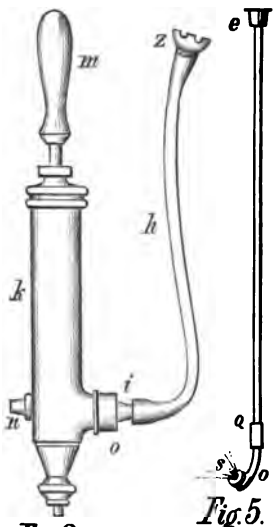

Fig. 2.

Fig. 5.

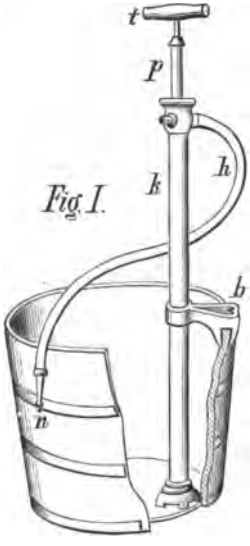

Fig. 1.

Fig. 6.

Fig. 3.

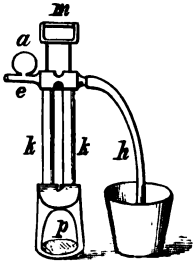

Fig. 4.

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HAND-PUMP AND BUCKET-PUMP SPRAYERS.

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Fig. 1.

Fig. 3.

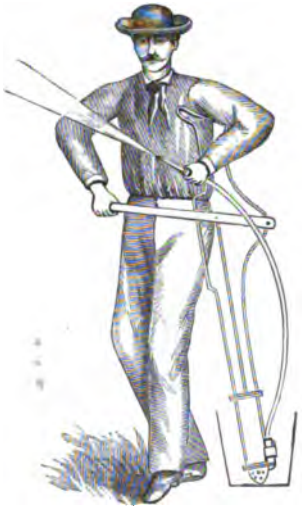

Fig. 2.

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DIVERS LIGHT SPRAY-PUMPS.

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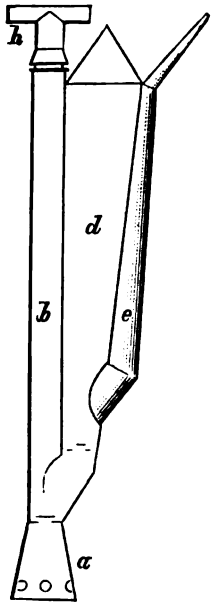
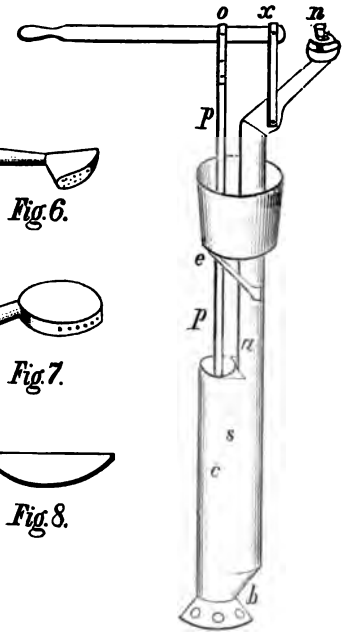


Fig.5.

Fig.6.

Fig.7.

Fig.8.



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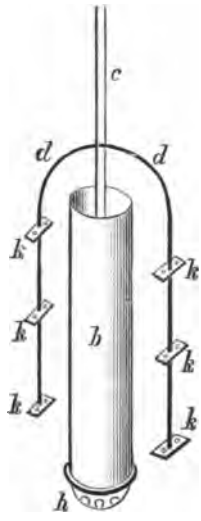

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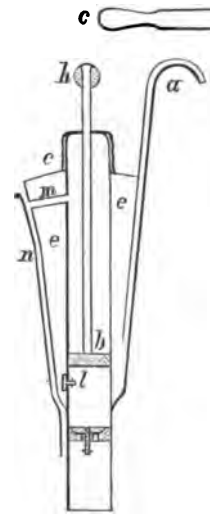

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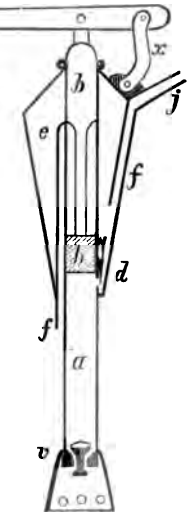

Fig.1.

W. S. B., Del.

LIGHT BARREL-PUMPS AND TANK-PUMPS.

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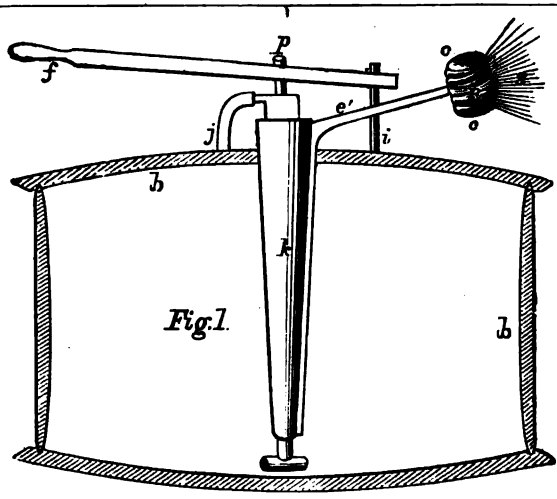

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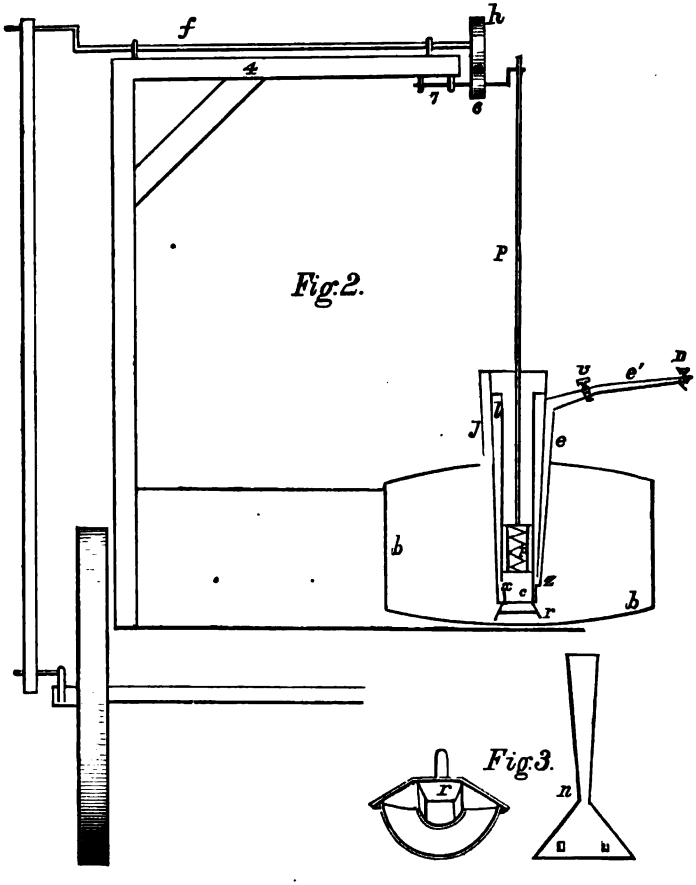

Fig. 2.

Fig. 3.

LIGHT BARREL-PUMPS.

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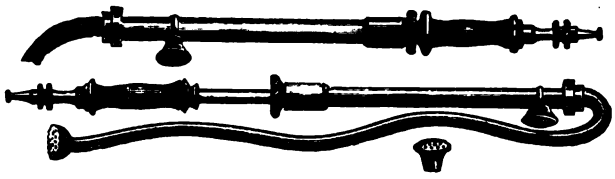

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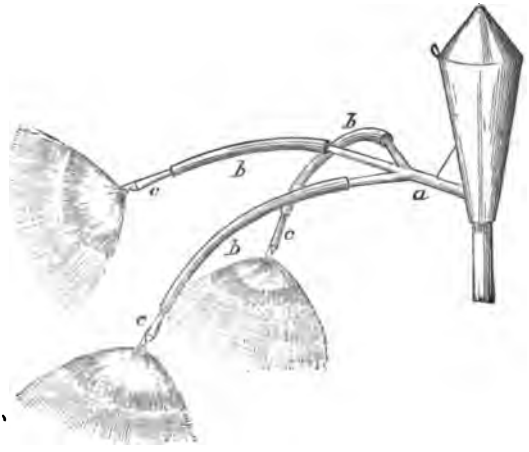

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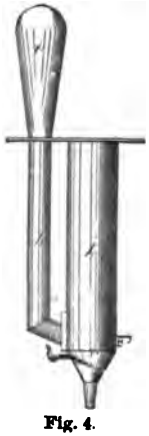

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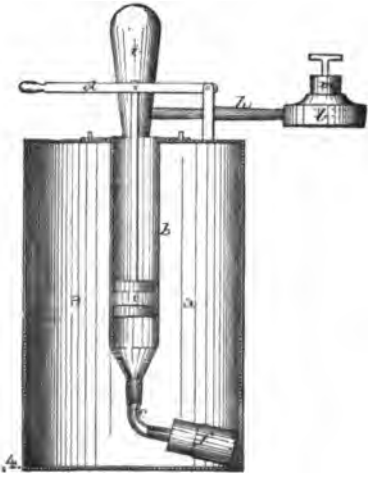

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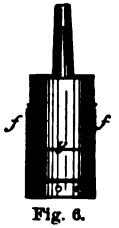

Fig. 6.

FOUNTAIN PUMP AND J. P. RUHMANN'S PUMP.

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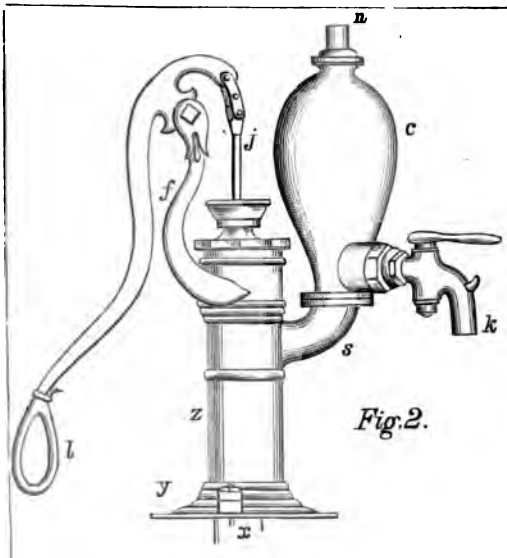

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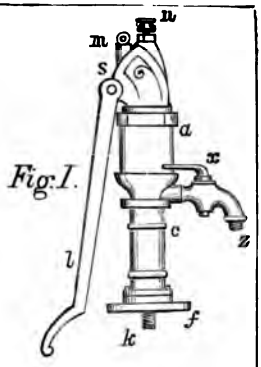

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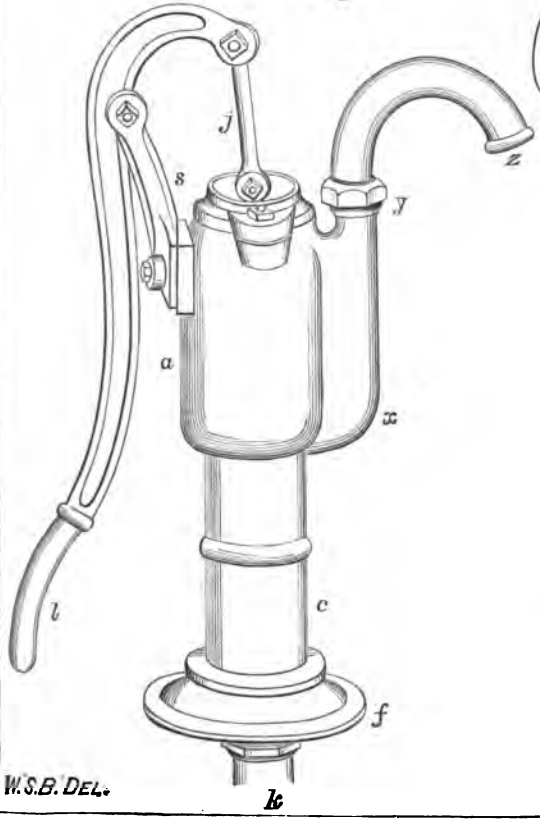

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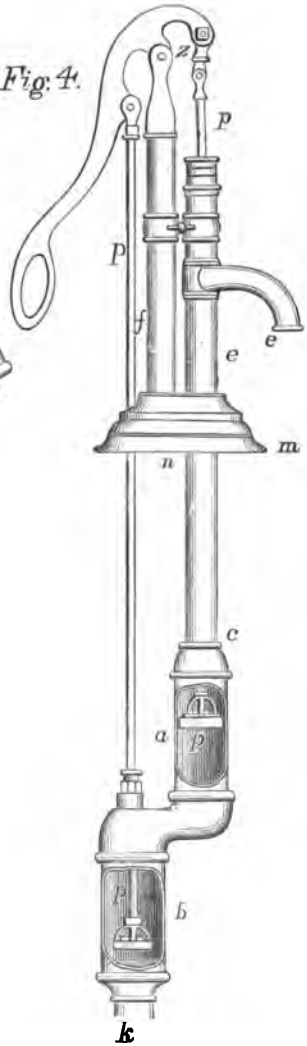

W. S. B. DEL.

AVAILABLE CAST PUMPS.

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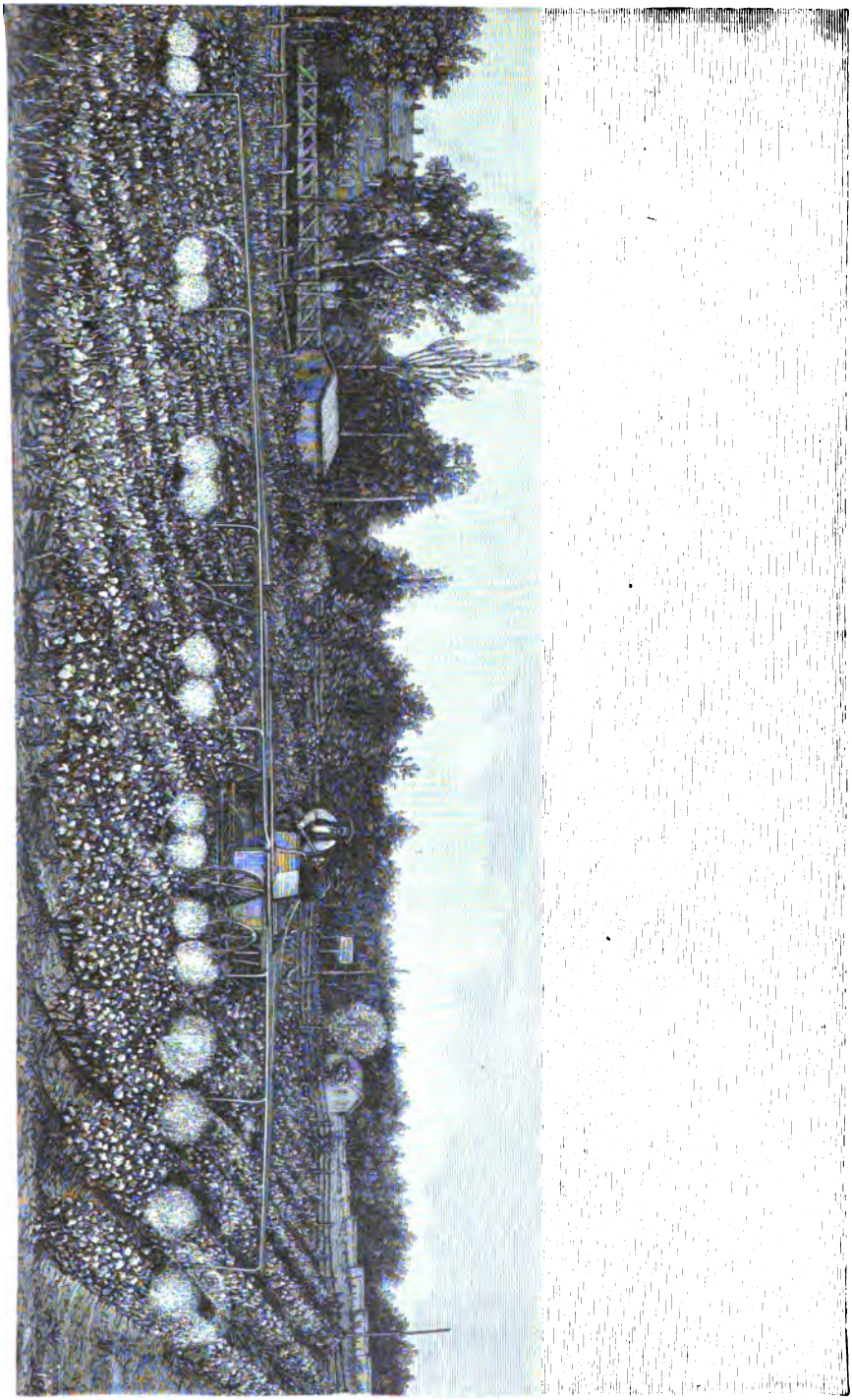

LARGE A-FRAME NETHER-SPRAYER, TO WAGON.

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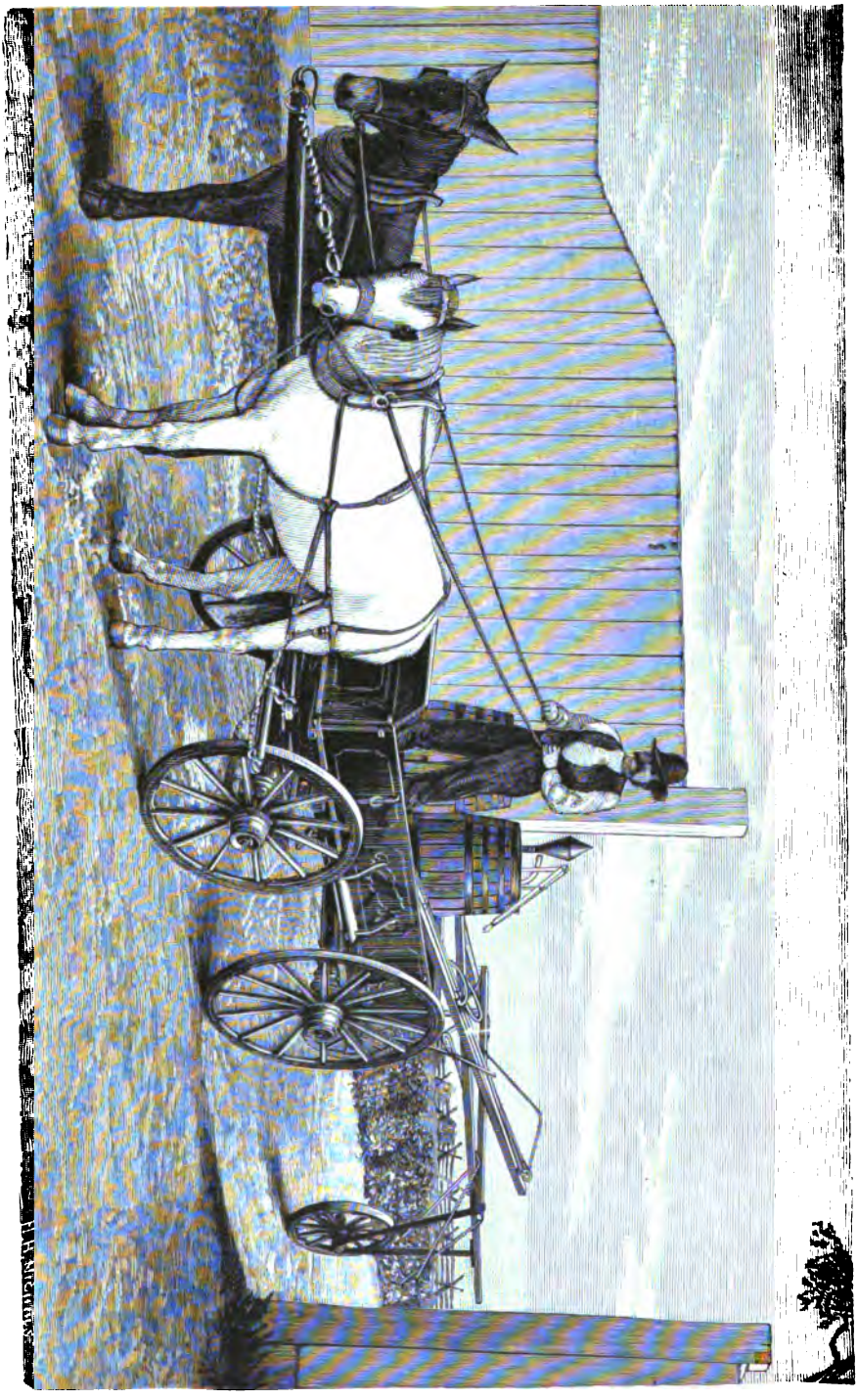

LARGE A-FRAME MACHINE, NARROWED.

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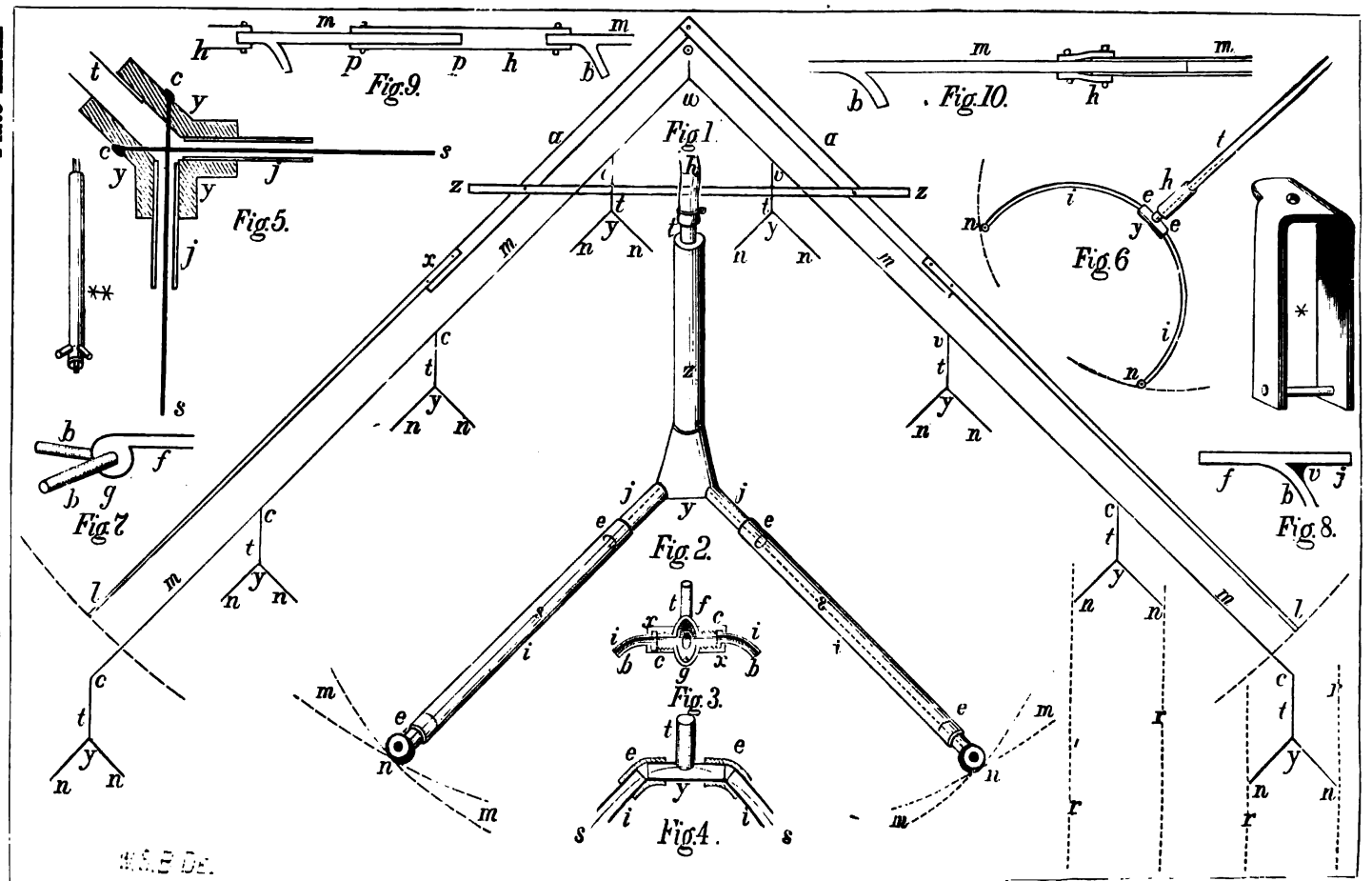

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WHEELED-TRIPOD, AUTOMATIC NETHER-SPRINKLER.

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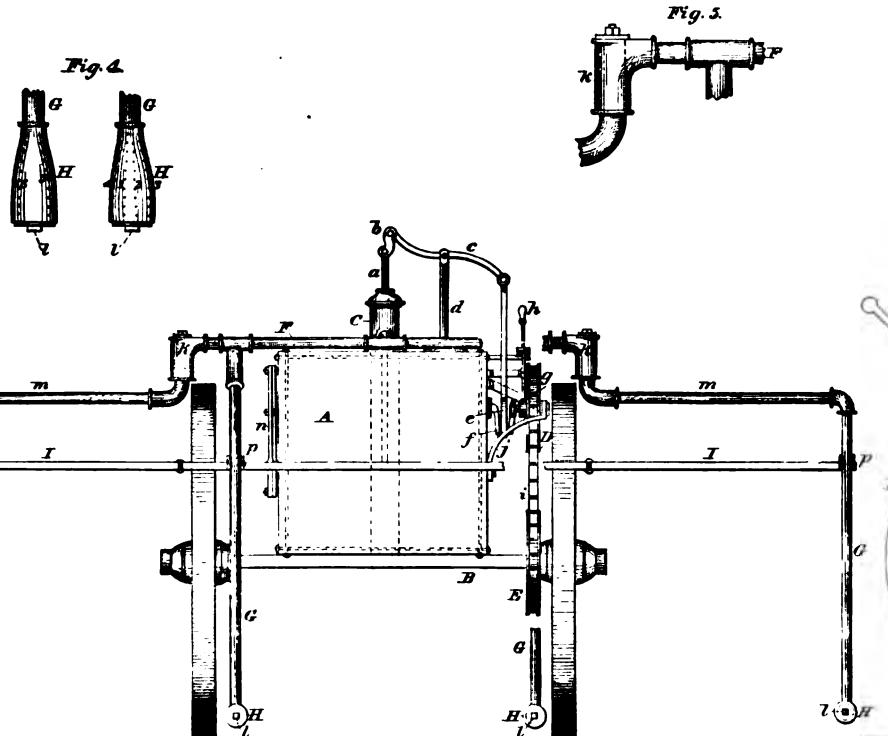

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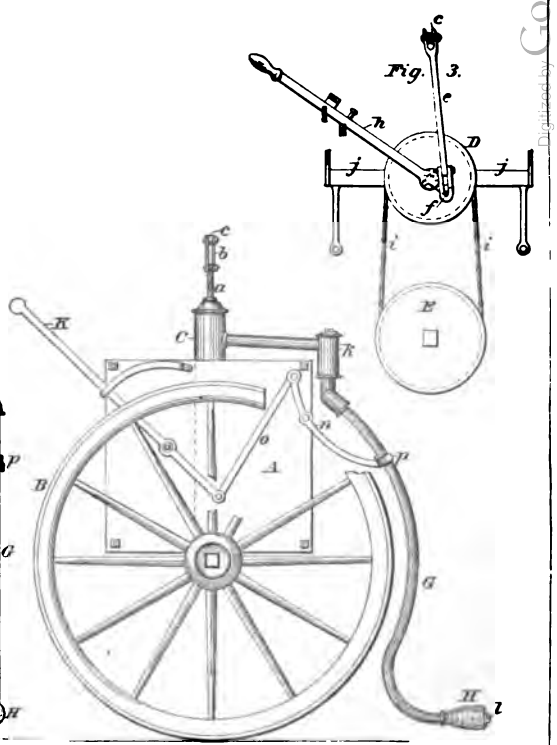

Fig. 2.

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WHEELED NETHER-SPRAYER.

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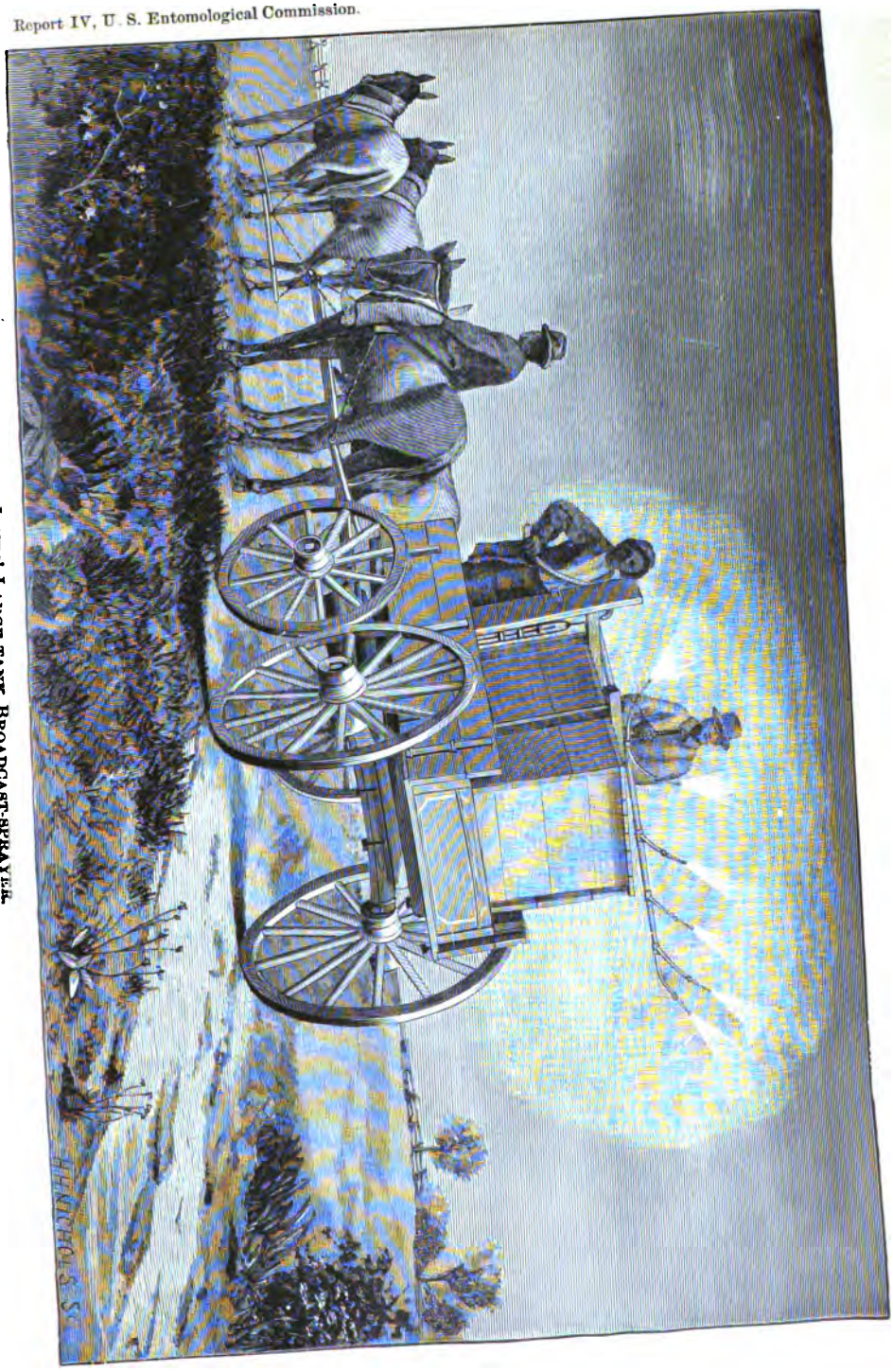

JONES' LARGE-TANK BROADCAST-SPRAYER.

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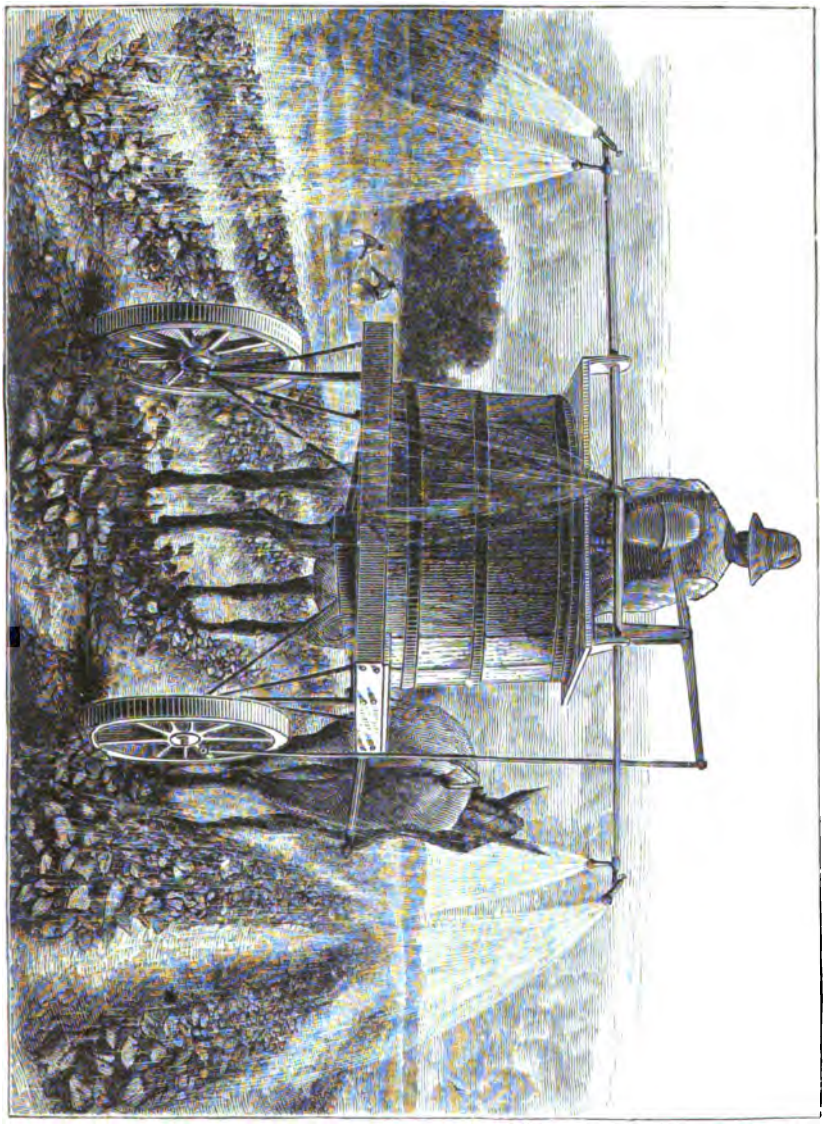

THE JOHNSON WHEELED SPRINKLER.

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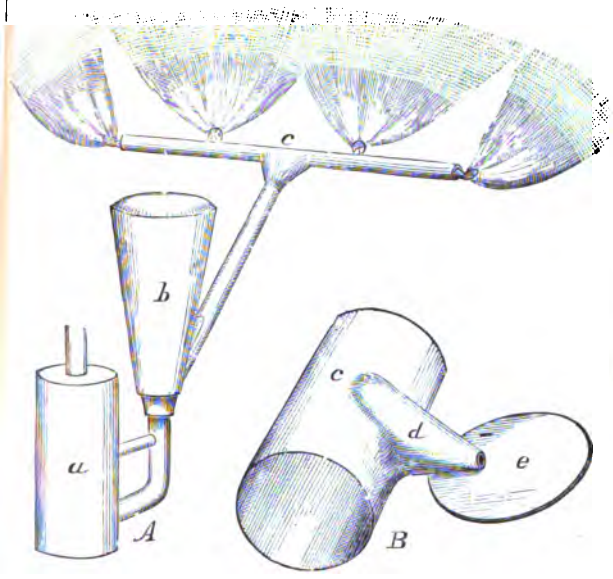

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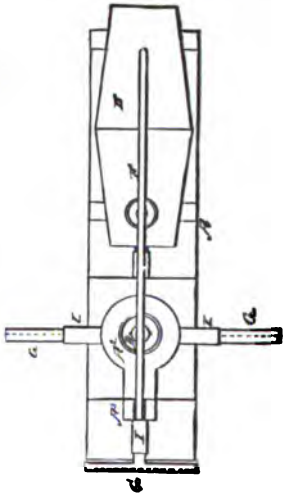

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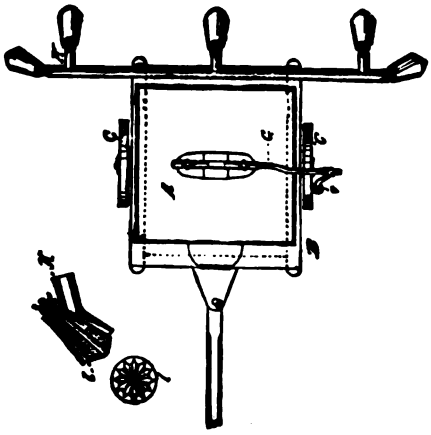

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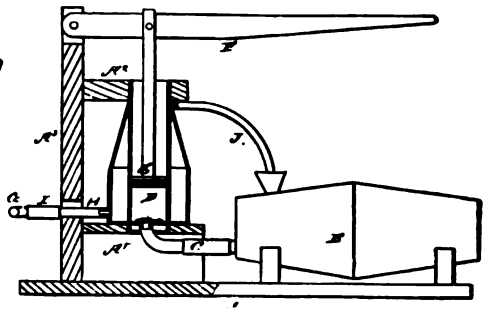

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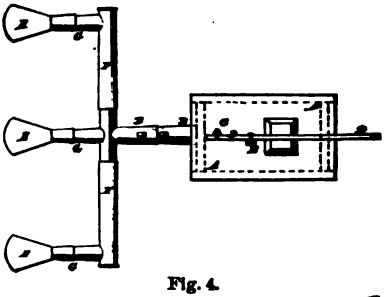

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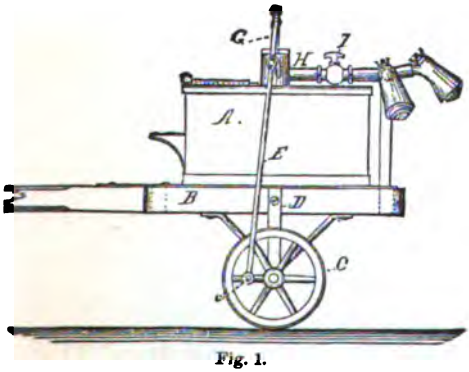

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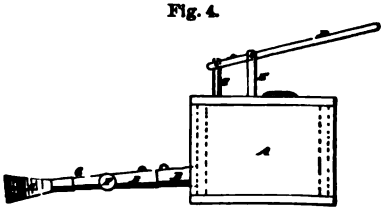

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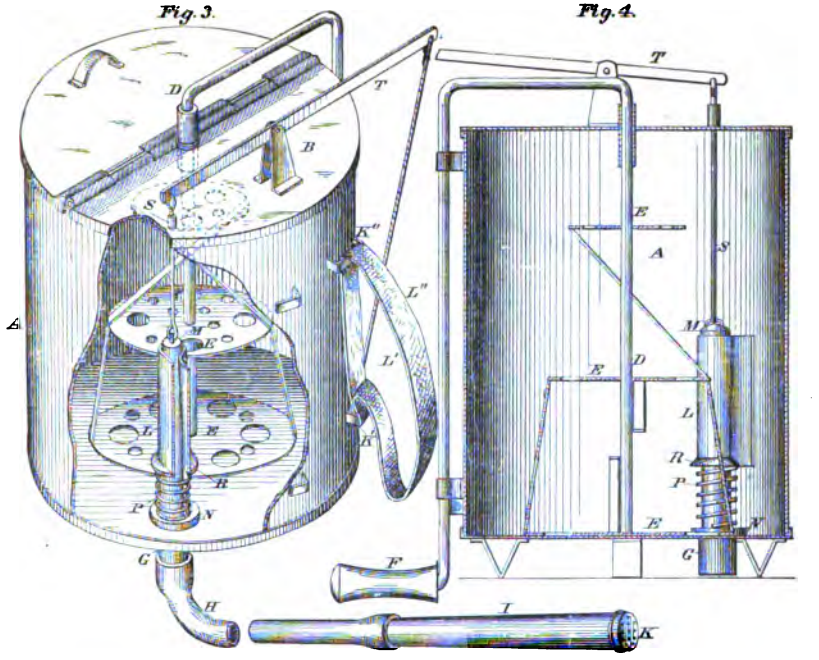

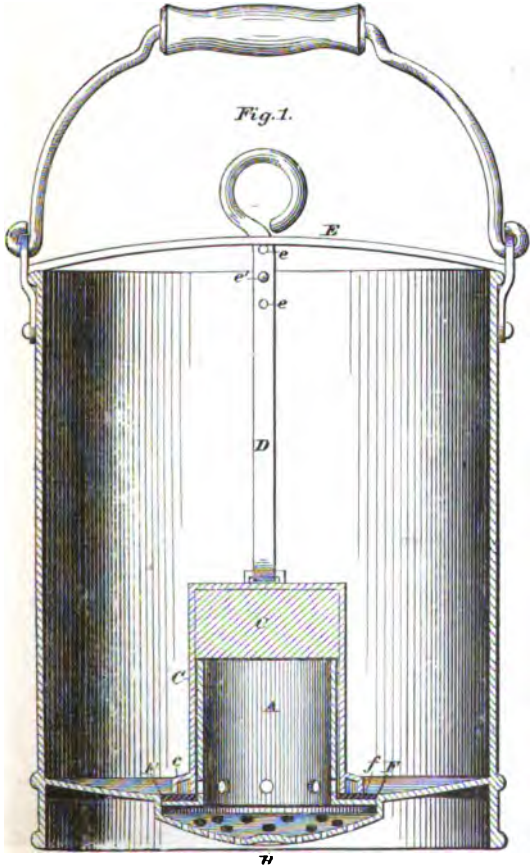

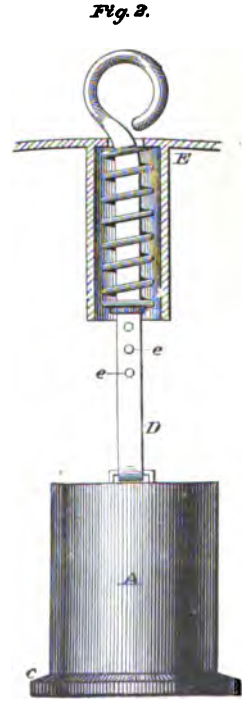

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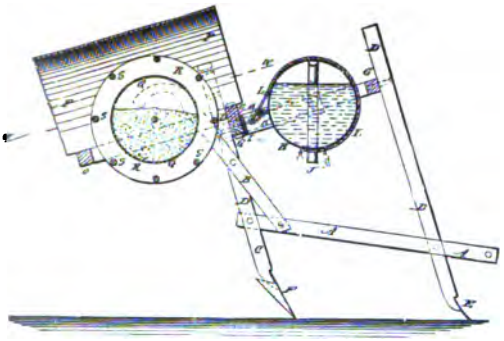

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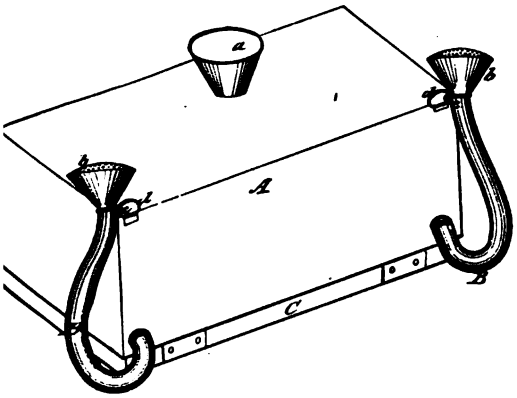

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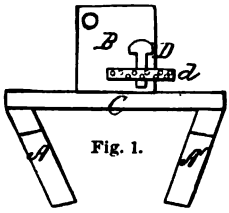

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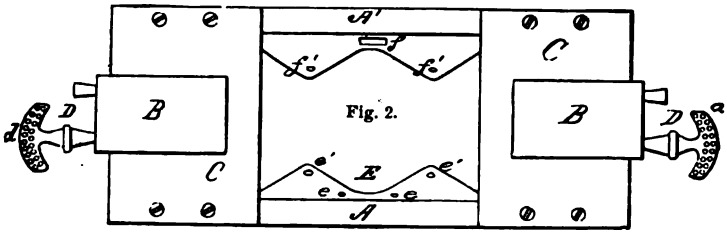

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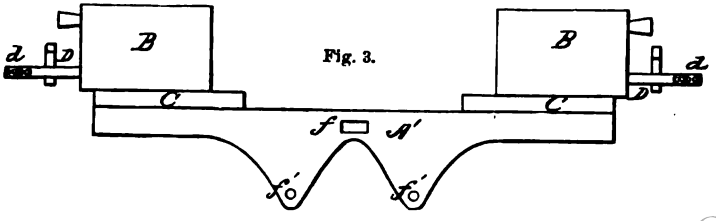

Fig. 3.

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KNAPSACK, HORSEBACK, AND PLOW SPRINKLERS.

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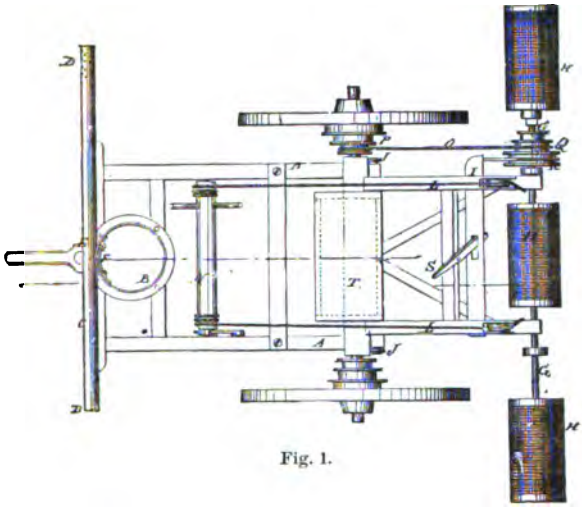

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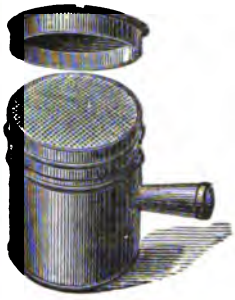

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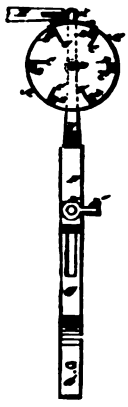

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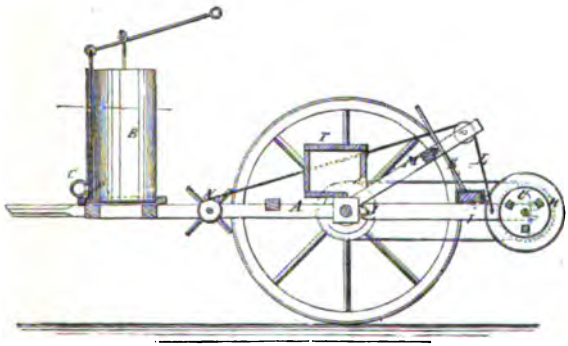

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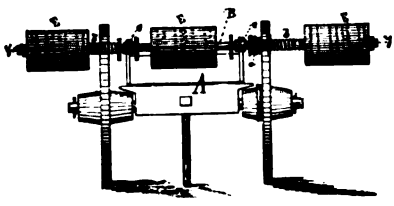

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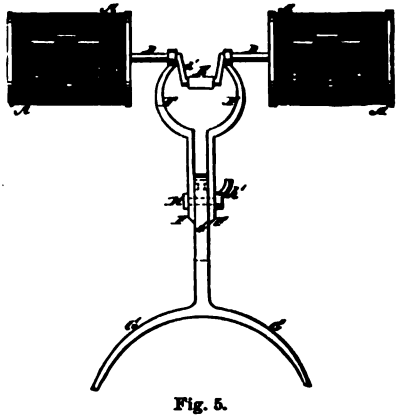

Fig. 5.

ROTARY-SIEVE MACHINES.

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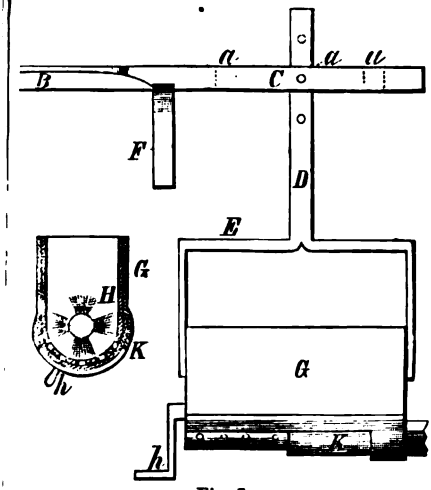

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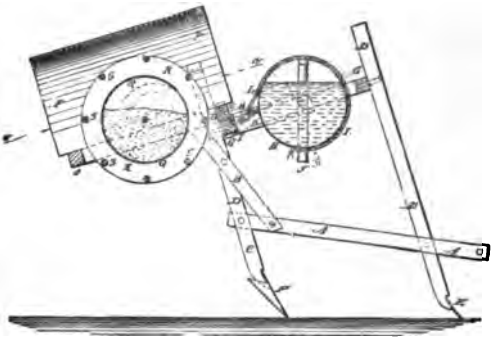

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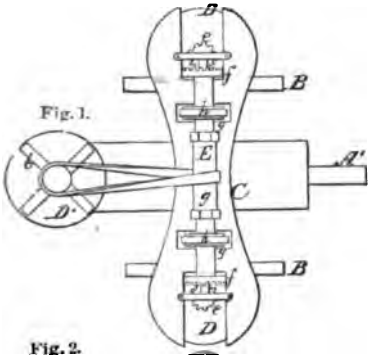

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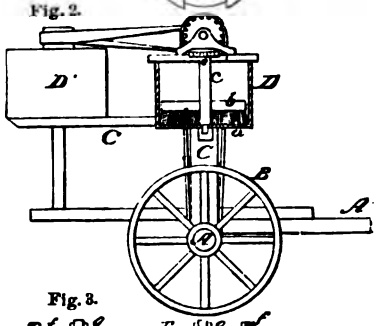

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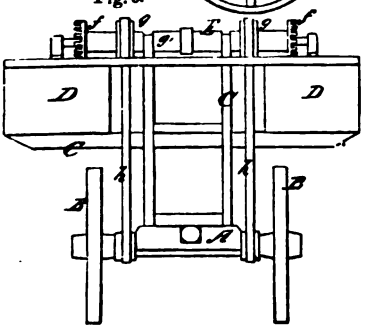

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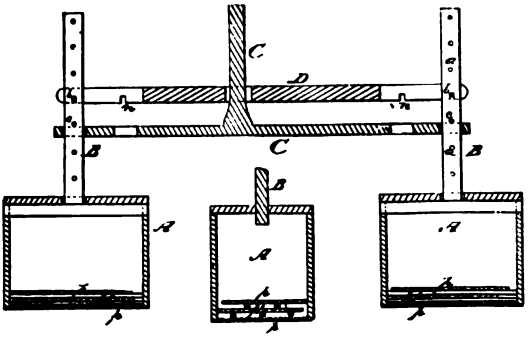

Fig. 4.

VARIOUS SIEVE MACHINES.

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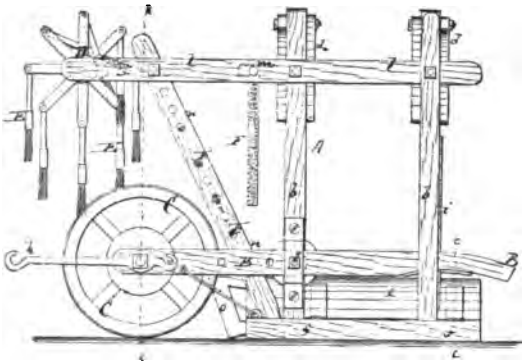

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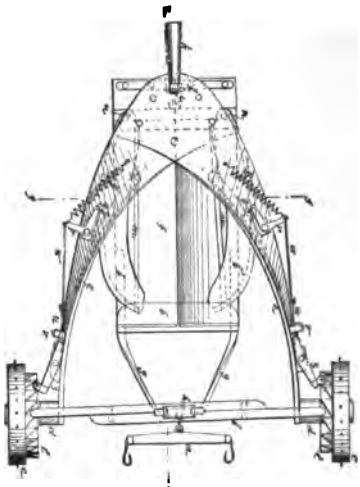

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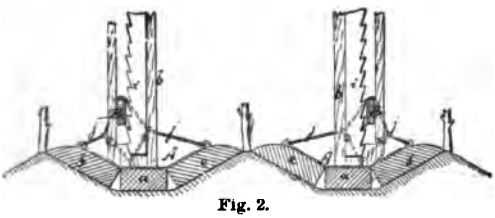

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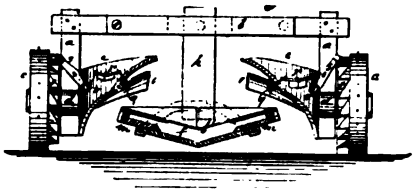

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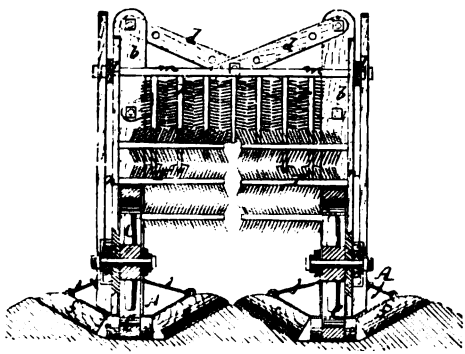

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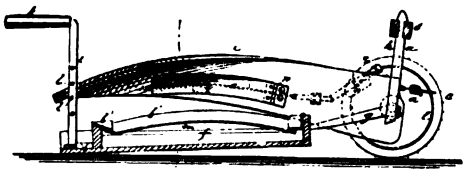

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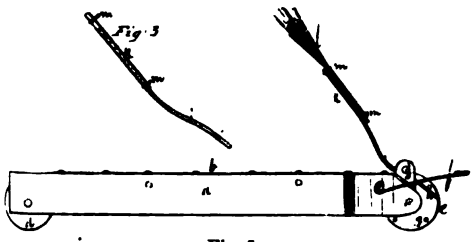

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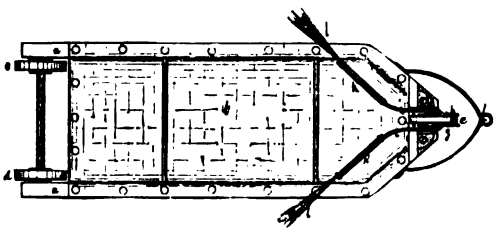

Fig. 4.

SWEEPING MACHINES.

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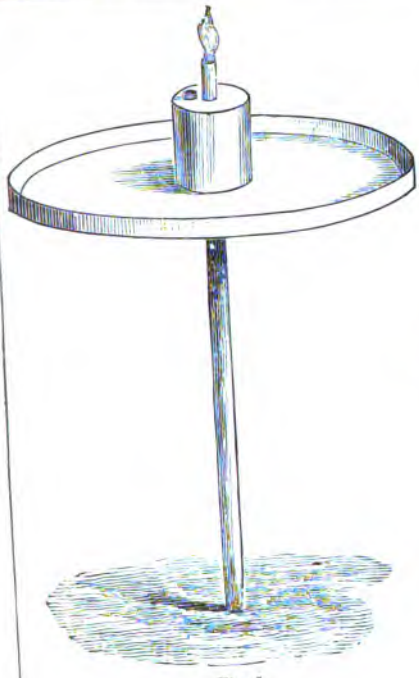

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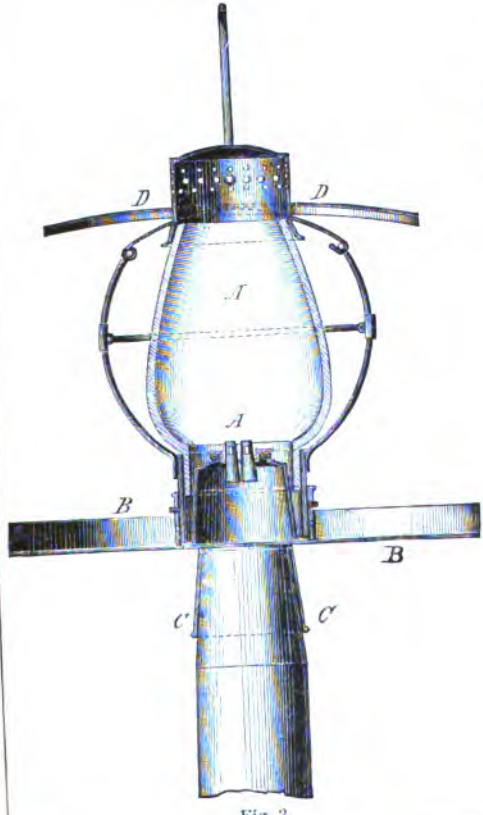

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VARIOUS MOTH TRAPS.

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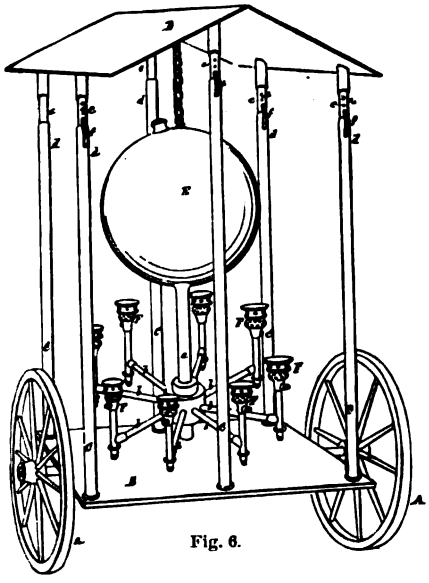

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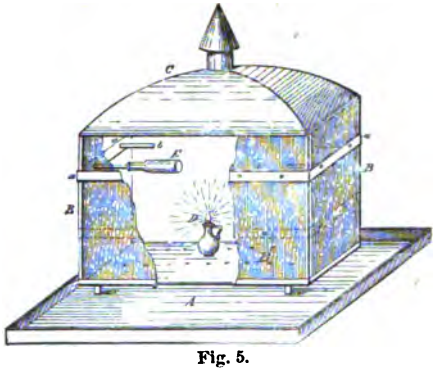

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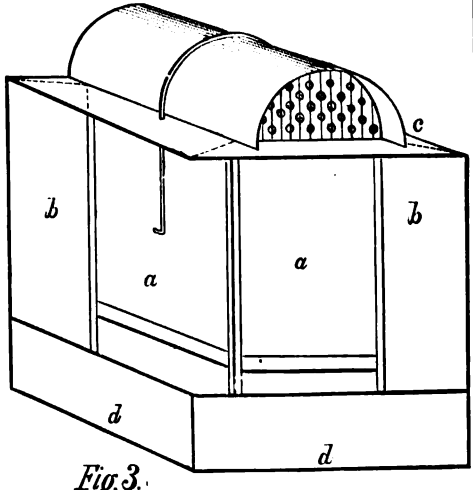

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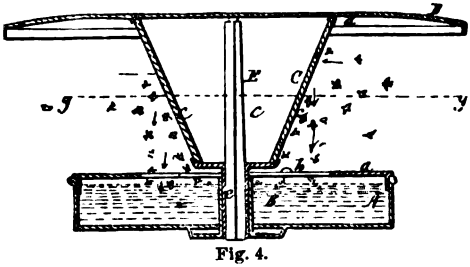

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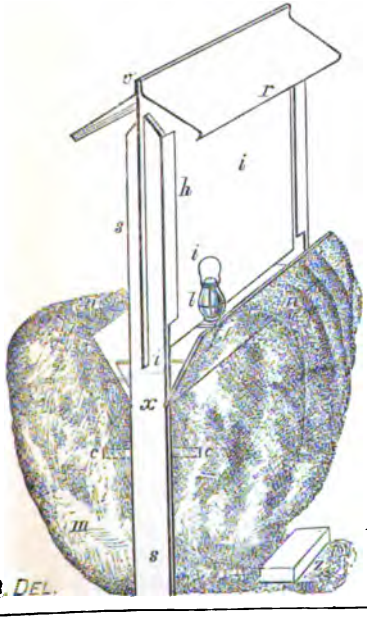

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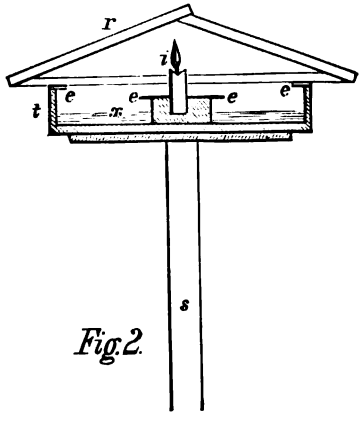

Fig. 2.

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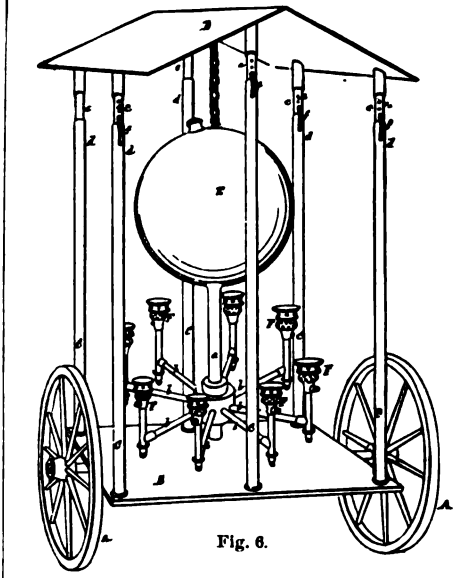

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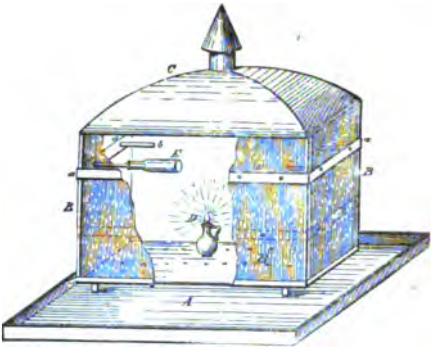

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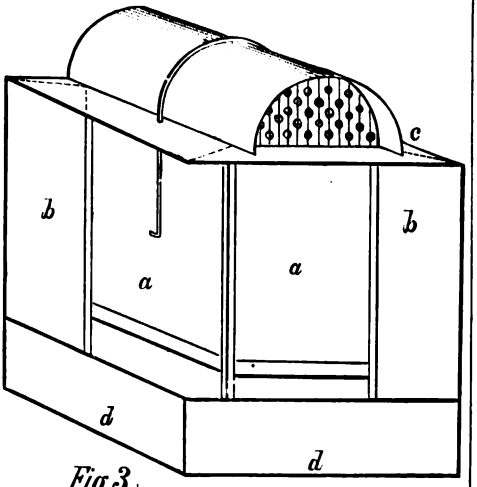

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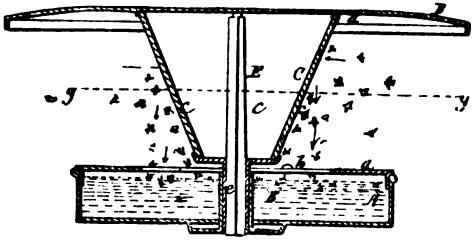

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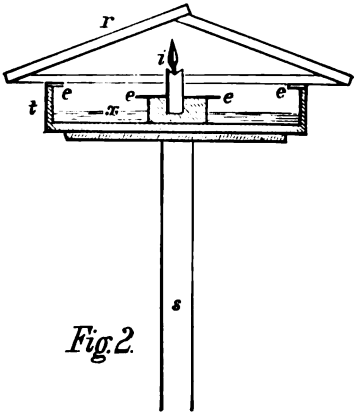

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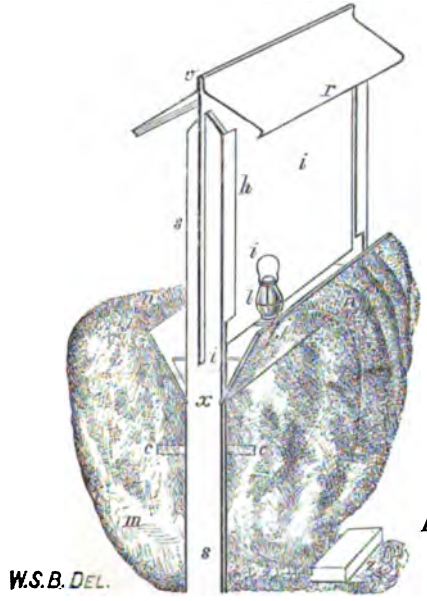

Fig. 1.

VARIOUS MOTH TRAPS.

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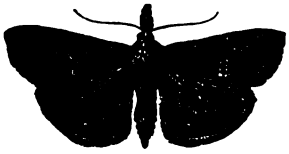

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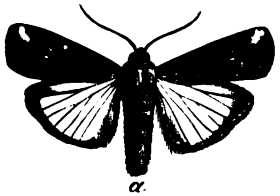

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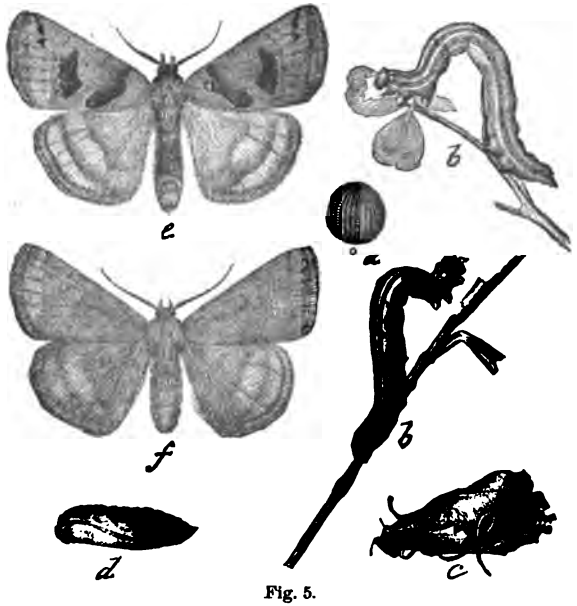

Fig. 5.

MOTHS MISTAKEN FOR ALETIA.

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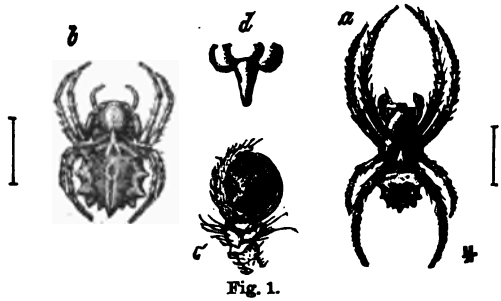

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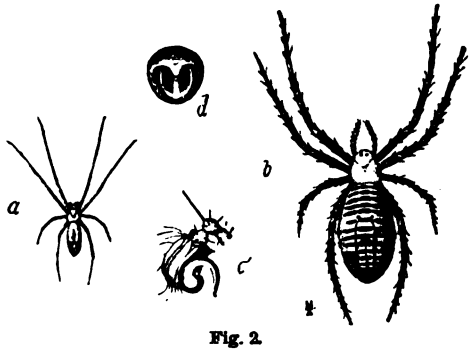

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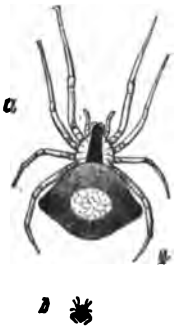

Fig. 3.

Fig. 4.

Geo. Marx, Del.

SPIDERS WHICH DESTROY ALETIA.

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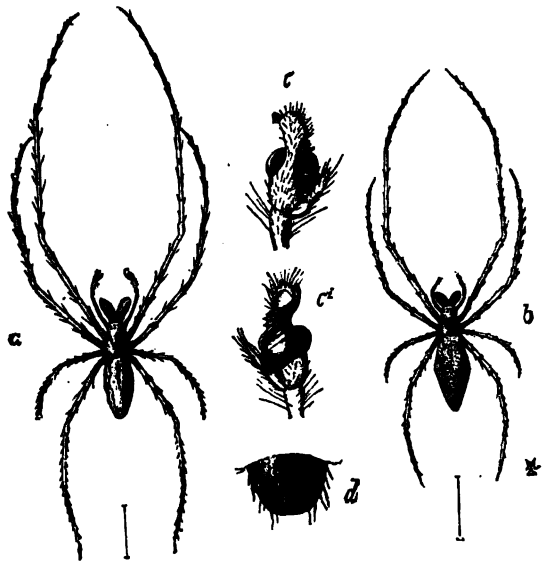

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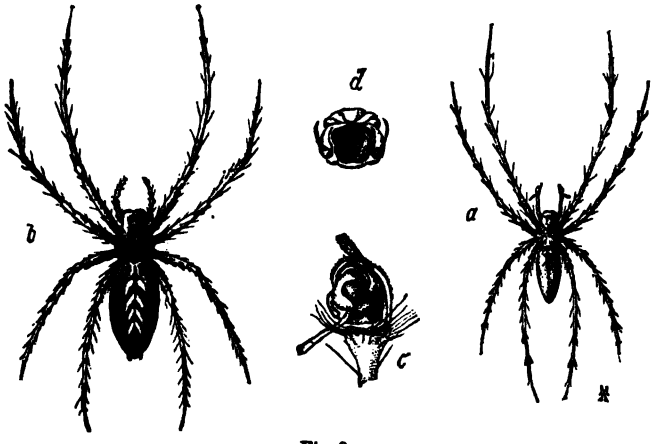

Fig. 2.

Geo. Marx, Del.

SPIDERS WHICH DESTROY ALETIA—Continued.

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APPENDICES.

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APPENDICES.

[The following appendices include such letters and reports as contain matter deemed worthy of being preserved and not fully used in the body of the work. Many of the reports of agents were received in the form of continued correspondence and have been utilized and quoted from in the different chapters. Others again have not been of such value as to warrant publication. Some of the replies to Circular No. 7 (see Introduction) are added in Appendix VIII, the replies being numbered to correspond to the questions. The reports as well as the answers to the circular are printed just as they were received and without comment, though it is hardly necessary to inform the reader who has perused the different chapters that the views and theories of the different writers are not necessarily indorsed. They are, rather, published to illustrate the conflicting views and theories held by the more intelligent correspondents.]

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APPENDIX I.

REPORT OF H. G. HUBBARD.

DETROIT, MICH, *August*, 1881.

SIR: I have the honor to submit herewith my report of observations made during the past season upon Aletia and other insect enemies of cotton, in the State of Florida. These observations, begun in Putnam County in the early spring, were extended during the month of June over portions of Alachua County, as far as Gainesville, in the heart of the long-staple district, and terminated in September at Centreville, in Leon County, near the Georgia line. During March and April I made an expedition along the east coast, from Daytona (latitude 29° 15′) to Jupiter at the southern end of Indian River (latitude 27°). In this thinly settled portion of the State, however, cotton is only exceptionally grown, but as it is in this region perennial, occasional plants are met with, which have escaped from cultivation, and still persist in the neighborhood of habitations deserted during the time of the Indian wars. Only one cultivated field was seen near Daytona, in which the plants, being in the second year of their growth, had attained a more than average height, and were at this date (March 27) in full bloom. They appeared to be free from the attacks of insect enemies. Regarding the latter, the information obtained from the settlers along the coast was too meager and unreliable to furnish a basis for speculation. Aletia appears to be unknown to them, and they complain only of the depredations of a "*red spider*," probably the rust mite.

In Putnam County, cotton has been raised for many years, but the acreage has never been large. The plants are killed outright only in exceptionally severe winters. The winter of 1879–'80 having been very mild, cotton remained in leaf and continued to bloom during the entire season. Notwithstanding these favorable conditions Aletia does not appear to hibernate here. The worms make their appearance every year, but always very late, and are not noticed by the planters until September or October.

At Crescent City, in the southern part of Putnam County, my observations, begun in February, were continued during the months of March, May, June, and the first half of July. During this time I made almost daily search for Aletia, but failed to find it in any of its stages. Only two fields of cotton were planted the previous season, in both of which the caterpillars were first seen in September, shortly after a severe easterly storm. After stripping the plants of their leaves, they "webbed up" in great numbers upon surrounding objects. In one of the fields young orange trees were growing between the rows of cotton, and to these they did some injury by completely occupying the leaves with their chrysalids. The cotton stalks put forth new leaves, and as there was no frost, continued to make a straggling growth during the winter. The later broods of Aletia appear to have been entirely destroyed by parasites. These in turn disclosed and disappeared, so that at the time of my examination none of the many pupæ examined were found to contain life of any sort. A small proportion had died from unknown causes.

A much larger acreage of cotton was planted the following year (1880) in the same and adjoining fields as well as in other parts of the county. I therefore confidently expected to find the first Cotton Worms in May or June. None were seen, however, until my return on September 12, when a single full grown caterpillar of Aletia was discovered, a prolonged search failing to reveal another. During the first half of June I made a trip to Gainesville, journeying overland, through unsettled portions of Putnam and into Alachua County, on the southeastern borders of which I found the first cotton-fields. Dr. F. M. McMeekin (Hawthorne), a large cotton planter, and very intelligent observer, furnished valuable information, a portion of which I quote from my notes:

"Aletia comes every year. The first worms are all green, slower in their development, and less voracious than later on. The planters all notice this, and some believe the early broods to be distinct from the later. They sometimes, when asked if they have the worm, reply that they have '*the green worm*.' By the middle of

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August worms of darker color begin to appear. Last year (1879) he lost half of his crop by ravages of Aletia. The worms were first observed 'as early as June,' in a low spot, a sort of sink-hole, in the middle of a field. In September they destroyed, in a few days, one-half of his crop. He used no remedies of any kind. In hoeing the cotton, every plant passes under the eye of the farm hand, who could, if he were intelligent or ordinarily observant, easily detect the worms when they first began, or soon after, and with little labor they might be checked. Negroes are, however, not competent to do this. They are superstitious, and very reluctant to destroy the worms, because of their belief in its 'divine mission.' Possibly, Chinese laborers might be trained to destroy the worms in this way. Dragon flies are seen every year to destroy numbers of the moths. They are particularly abundant in Florida.

"More dreaded, in this section of the country, than Aletia, is the 'Red Bug' (*Dysdercus suturellus* Herrich-Schaeffer), a coral-red Hemipteron, with elytra edged with white. It appears in the field as soon as the bolls begin to ripen and crack. It sucks only the seed, but stains the cotton, and injures the fiber. In some years they destroy every boll; in others do little damage. They are more destructive in the southern counties, and do not appear to range very far north of this point."

Underneath Dr. McMeekin's gin house I found the "Red Bugs" in countless numbers and in all stages of growth; many of the adults were in copulation, but the eggs could not be found. They were running over piles of waste cotton seed, upon which they lived exclusively.

At Gainesville a political convention was in session, and I met and conversed with many cotton planters from different parts of the State. Few of these gentlemen had information of much value to impart. In regard to Aletia, their knowledge had generally been derived from experience in other States, and I was struck with the small importance attached to its depredations, especially in the southern portions of this State. It was universally reported to make its appearance so late as to do but slight injury in ordinary years. From Mr. W. H. Robertson, of Gainesville, I obtained the following notes: "Aletia comes later now than formerly. In 1871–'72–'73–'74 the worms did much damage. In 1874 the cotton was all eaten up by August 21. They began to be very numerous about August 18. On August 21; having eaten all the cotton, some of them went to work on sugar cane in an adjoining field, but soon died upon it. In 1875, they were not observed until just before frost came, and were all killed by the cold. The worms always appear first in a particular part of the field, usually where the growth is rankest, and this with such absolute certainty that if not found there they need not be looked for in other parts of the field. They never attack the cotton until it has reached a certain maturity. He has never seen the worms before the end of June, usually not until late in August; sometimes not before October. Last winter, at Gainesville, there was frost, and even ice three or four times during the winter, but it did not seem to do the least harm to vegetation, and did not kill or injure young tomato plants. He thinks the frosts, which lasted only a few hours, would not have killed the pupa of Aletia.

"The 'Red Bug' (*Dysdercus*) has never been known to destroy a crop in this part of the county. If cotton is planted three times in succession in the same field, the 'Red Bug' appears with certainty. It injures the sale of cotton, staining it yellow. Sometimes a few bales have to be picked over because of it, but it never has done much harm here. He used to have a few Boll Worms, but has not seen them for eight years. Cut-worms are sometimes bad in sandy soil. Red Bug is only bad in rich 'hammock' land. Never has had the Northern Army-worm. Some short-staple cotton is planted, but usually long-staple. Mr. R. thinks the short-staple is more subject to attacks of Aletia than the long-staple. No one uses Paris green or other poisons because of the great difficulty of applying them on long-staple cotton, which makes a very heavy growth. At this date (June 10), when riding through the cotton, the tops of some plants can be locked over the saddle-bow, and later on it will be much higher."

John S. Livingston (Orange Springs) says, "Red Bug (*Dysdercus*) was bad thirty to thirty-five years ago, but has not done much damage since. The caterpillar (*Aletia*) came after the Red Bug ceased to do injury. Twenty-two years ago Aletia was very bad for the first time everywhere in the State. There had been a few for ten to thirteen years before."

Isaac Roberts (6 miles from Gainesville) has lived here since 1833, at which time this part of the State was wilderness, and no cotton raised. He thinks the caterpillar was known to damage cotton where raised in more northern portions of the State at that early date. In Alachua County, which at that time included all the country between the Saint John's and Suwannee Rivers, cotton was not raised until after 1842. The worm was here at the earliest date. He has never seen Aletia earlier than July, generally not before August 1. It frequently does not appear until October, as was the case last year (1879). He never has been damaged by Red Bug (*Dysdercus*), and knows very little about this insect from personal experience. They are seen in his cotton, but not in sufficient numbers to do harm.

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The experience of many other planters does not differ materially from that which has been already given.

The soil of eastern Florida is, with few exceptions, light and sandy. To this is very generally attributed the prevalence of Cut-worms (various Noctuids, including *Heliothis armigera*), which do much injury to cotton as soon as it comes up, cutting off the young plants at the surface of the ground. A black cricket, which I have not been able to capture, has the reputation of doing injury in the same manner. Like the Cut-worms it is nocturnal, and lives by day in long burrows under the sand. To the poverty, or some other quality of the sandy soil, is often laid the ruin caused by "rust," than which no greater pest of the cotton plant exists. I am, however, of the opinion that "rust," a fungus which attacks the parenchyma of the leaves, causing them to turn red and fall, and ultimately blasting the entire plant, is a direct sequence to the attacks of a mite, always found more or less infesting cotton. It will be referred to in this report as the "rust mite," and is, perhaps, identical with the "red spider" of the planters. Some other insects depredating on cotton in East Florida will be treated of later on.

On July 14, Aletia not having made its appearance at Crescent City, at Professor Riley's direction I removed to Leon County, and took up my residence at Centreville, twelve miles north of Tallahassee, with Mr. T. J. Roberts, who kindly received me upon his plantation, and during my seven weeks' stay was most assiduous in offering me every assistance within his power. Mr. R. is widely-known as a keen observer, and is invariably the first to report the appearance of the caterpillar in this State. Two full-grown worms were found by him this year on the 5th of June. In former years he has found them as early as May 9.

At the time of my arrival Aletia had evidently passed through several broods. The caterpillars, although by no means abundant, were found in all parts of the plantation. This Mr. Roberts considers unusual, and attributes to the remarkably even growth of the cotton this year, which is not ranker in one part than in another. Other planters in the neighborhood had begun to report the caterpillar as occasionally seen, especially on low ground. The moths were also seen in small numbers. About the first of August there was every indication that unless a vigorous fight was made, by the application of poisons, a clean sweep would be made by the caterpillars during the month. Not only were their "webs" (pupæ) scattered over the entire acreage, but also in several places patches of five or six acres were entirely denuded of leaves, and the moths had there appeared in great numbers. By the 6th of the month the moths were seen everywhere about the plantation, and eggs were laid by millions in every part of the cotton fields. The worms of the next brood, however, failed to appear in great numbers, as about 90 per cent. of the eggs were destroyed by the Trichogramma egg parasite (*T. pretiosa* Riley). During the remainder of August this and other parasites, which made their appearance in greater abundance as the season advanced, successfully held the worms in check. By the first of September the caterpillars were so nearly exterminated that it became difficult to obtain them in sufficient quantities for experimenting with poisons. On the 5th of September I left Centreville, and, after paying a flying visit to Crescent City, where, as before related, I found Aletia just making its appearance, I returned to Washington. On the return I made an excursion to Selma, Ala., and there for a few days assisted other observers in making experiments with poisons, the details of which will be given elsewhere in their reports. After leaving Centreville I had the misfortune to lose, with a portion of my baggage, a large part of my field notes and a number of microscopic slides with parasites and other minute insects infesting cotton, a loss which will, I fear, seriously impair my report upon a large and important part of my summer's work.

ALETIA.—SUCCESSION OF BROODS.

An examination of all the data obtainable gives the following as most probably correct for the succession of the different broods of Aletia at Centreville during the season of 1880. First appearance of the caterpillar (first brood), early (?) in April. Second brood, from the middle of May to the middle of June. (On June 5 two full-grown caterpillars were taken by Mr. Roberts; they "webbed up" on the following day). Third brood, from June 15 to July 15. Fourth brood, from July 15 to August 9. Fifth brood, from August 9 to September 3.

On my arrival (July 16) a few full-grown worms and pupæ were found in different parts of the cotton fields. These are presumed to have been lagging individuals of the third brood, and were soon re-enforced by numerous young worms and eggs of the fourth brood. July 26, the following entry occurs in my note book:

In the main field of 200 acres the worms are still very much scattered, but their number is increasing over its whole extent—that is, they are working up from below, and appearing in sight upon the upper and outer leaves of the plants as they increase in size. A portion, about 5 or 6 acres, of this field was planted at least twenty days later than the rest. I shall hereafter designate it as *the young cotton*. It is now

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of the same height as the surrounding cotton, but has fewer maturing bolls. A part of this young cotton is in a hollow, where it grows very tall and rank; the remainder stretches up the hill-sides on either hand. The portions on the hill-sides are now very much "ragged," some plants having nearly every leaf eaten. The portion in the bottom is least attacked of any, though not by any means free from worms. The worms in this young cotton are beginning to web up in large numbers. Of the leaves now being folded, the greater number contain larvæ just beginning their webs; next in point of numbers are leaves containing larvæ not yet in pupa; and last, fully formed pupæ. I gathered at random 25 or 30 pupæ, all of which had their full color. All the pupæ were placed head toward the base of leaf. About one quarter of the unchanged and feeding larvæ in sight are dark colored. I find a few pupæ from which moths have already disclosed. Very young larvæ and eggs are also common, as well as every intermediate stage. I have seen very few moths anywhere, none at all among the "young cotton." There is, however, a corner of the field through which passes a ditch, along which the cotton plants are more widely separated, and grow low and spreading, giving dense shade close to the ground. Such plants evidently afford acceptable lurking places for the moths during the daytime. The first seen were found here, July 17, and I have since started a few whenever I have passed through this part of the field. I do not think the moths give these plants the preference in depositheir eggs, and the worms are not more numerous here than elsewhere. The following is a detailed examination of one such plant, selected for medium height, spread, and general development.

Plant No. 1, July 27.

Number of leaf.	Very young larvæ.	Larvæ one-fourth to one-third grown.	Larvæ one-third to one-half grown.	Larvæ two-thirds to full grown.	Larvæ changing to pupa.	Pupa.	Eggs.	Character of leaf.
4			1 gn					
5			1 gn					
6					1 gn			
7			1 gn					
8			1 gn; 1 bk	1 bk				
10						1		Axillary leaf
11			1 gn					
14							×	
15				1 bk				
16			1 gn				0	Axillary leaf.
18				1 gn				
(20)							×	Involucre of flower-bud.
21	1 gn	2 gn	2 gn; 1 bk	1 gn; 2 bk			×	A large leaf, badly ragged.
22			1 gn					
23	1 gn						×	Young but full-grown leaf.
24	1 gn		1 bk	1 bk				Full-grown leaf, badly ragged.
(25)							×	Involucre of flower-bud.
26	×	1 gn						Stunted, axillary leaf.
29			1 gn					Old, large leaf.
30			1 gn				×	Do.
36							Hatched shell.	Young leaf, egg-shell on upper surface.
(36)							×	Involucre of flower-bud.
39			1 gn				×	Large leaf, hardly ragged.
46	1 gn	1 gn						Axillary leaf.
48	1 gn							Badly sanded leaf.
58	1 gn							Immature leaf of a sprout at base of stalk.
6′			2 gn				×	A large branch joining main stem at base, with seventeen leaves, less mature than those of main stalk.
9′			1 bk					
11′		1 gn						
14′	1 gn							
15′	1 gn							
	8	5	18	7	1	1	10	

The main stalk bore sixty leaves, of which twelve were immature and but slightly fretted by larvæ. The leaves are numbered from the top downwards, Nos. 1 to 26 being upon the upper half, Nos. 1 to 60 upon the lower half of the plant. The lower leaves were all somewhat sanded. gn. indicates worms of green color; bk., those with dark bands; × indicates eggs parasitized by Trichogramma and turning black; the single sound egg is marked 0.

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As the moths live and continue to lay eggs for many days, it follows that the successive generations rapidly become intermingled and confused. Any division into exact periods is therefore hypothetical, but the maximum number of generations can be arrived at with certainty by combined observations in the field and in vivaria.

The following statement exhibits in tabular form the conditions observed in the field, together with the periods of time occupied in each stage of growth, as determined by numerous experiments made from time to time in vivaria indoors and under nettings in the field:

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Tabular arrangement of field notes.

Broods, 1880.	Succession of generations.			
1. April and May.	This brood escaped observation in 1880. The earliest worms seen in former years, May 9.			
2. May and June.	Two full-grown larvæ found June 5, which webbed up the following day. Moths probably disclosed about June 17.			
3. June and July.	No observations of this brood. Probable length of time from egg to moth at this period, 30 days.			
	Moths.	Eggs and young larvæ.	Larvæ from one-fifth to full grown.	Pupæ.
4. July 15 to August 9. Incubation of egg, 3 days. Larval period, 9 to 14 days; average, 12 days. Duration of pupal period, 8 to 11 days; average, 9 days. Average time from egg to moth, 24 days.	July 17, seen in one corner of field. July 30, young cotton eaten in strips, many plants entirely stripped of leaves. Black begin to outnumber the green larvæ. Majority still feeding, but many webbing up. August 2, beginning to disclose. August 5, great numbers have disclosed. August 7, still disclosing in great numbers during the first half of night. August 9, seen everywhere in field.	July 17, eggs of fourth brood are probably now being laid. July 20 to 25, occasionally seen. July 26, on infested young cotton, proportion of young to older larvæ, 1 to 5; proportion of eggs to all other stages, 1 to 5. July 28, decreasing in numbers. Eggs occasionally found.	July 17, a few seen in all parts of the field (probably stragglers from third brood). July 20 to 25, appearing in increasing numbers on upper leaves. Nearly all green. July 26, a brood center found in young cotton, worms here very abundant, cotton becoming ragged. August 5, the majority have pupated in the last three days. August 7, the last worms webbing up in the young cotton. August 9, very few to be found anywhere.	July 17, none found. July 26, occasional in young cotton. July 30, number rapidly increasing. August 5, not yet one-half have disclosed the moths. August 9, in some parts of field most of the pupæ found are empty.
5. August 9 to September 3. Incubation of egg, 3 days=72 hours to 84 hours. Larval period, 9 to 16 days; average, 10 days. Period of pupa, 7 to 8 days; average 8 days. Average time	August 10, swarming everywhere. August 17, very abundant about fallen persimmons. August 20, at oak tree some moths seen, but those of last generation fast disappearing. August 28, last generation in great part gone. At oak tree new generation rapidly disclosing, but not in equal numbers to the last brood. September 2, severe storms and	August 10, young cotton in new leaf. August 11, eggs laid in all parts of field, but more than half parasitized by *Trichogramma*. August 15, very few leaves which do not bear from one to six eggs, but 90 per cent. or more are parasitized. Young larvæ attacked by many enemies. August 16, young larvæ not abundant. August 20, at oak tree very few eggs or young larvæ.	August 10, none seen anywhere in neighborhood of young cotton. August 16, very few worms found in the fields (scattered remnants of previous brood). August 20, a brood center found at a distance from the young cotton; here larvæ of all sizes; cotton ragged (locality marked by an oak tree). August 26, nearly all webbed up at oak tree.	August 10, many still not vacated. August 11, two-thirds vacated. August 12, four-fifths vacated. August 20, at oak tree a few pupæ found. August 22 to 25, at oak tree many pupæ. August 28, at oak tree many pupæ vacated. Pupæ nearly all vacant.

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from egg to moth, 21 days.	constant rains for the past week, ending in a tempest. A few moths about fallen fruit. September 4, observations closed.	August 20 to 28, young larvæ all destroyed by *Microgaster* parasite. August 28, very few eggs in the young cotton. Great numbers of empty shells from which parasites have disclosed. At oak tree eggs not abundant. Eggs and young all destroyed by parasites.	August 28, few left at oak tree; none in other parts of the plantation. No worms anywhere.

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As the earlier broods did not fall under my observation, there may be a question as to their number, but the season of 1880 being an early one, it is probable that the first brood was no later in making its appearance than in former years, when grown worms were seen early in May. In this case the first brood will have begun in April. The two larvæ found by Mr. Roberts on June 5, and which pupated on the following day, will then fall into the second brood; and the moths appearing about the middle of the month, an interval of thirty days remains to be occupied by the third brood. During this period the eggs were scattered over the entire plantation, and as their deposition was probably continued many days, the succeeding generations became confused.

The past season has been hot, and with an unusual amount of rainfall, particularly during the month of August, conditions which are usually regarded as favorable to the development of Aletia, and unfavorable to enemies, but which at Centreville do not appear to have hindered in the slightest degree the spread of certain parasites—notably the minute egg parasite (*Trichogramma*).

My observations upon the egg of Aletia simply confirm what has been already noted by other observers, and I have not thought it of advantage to multiply tables which would give results not differing materially from those shown in the one already produced. I found the eggs almost invariably deposited on the under side of the leaf, often close to but very rarely upon a vein. Exceptionally they were found upon the upper surface of a leaf, and in one or two instances upon the involucre of a flower. In July an undue proportion appeared to be deposited upon axillary leaves, i. e., those growing upon the main stalk, in the axils of branches. Such leaves are often aborted in size, have smooth surfaces, and, though very mature and tough, are seldom rusted or infested with plant lice. They appear to afford the most favorable food material to the very young larvæ. The middle third of most plants bears the greatest number of eggs, although the lower leaves, even when much sanded, are often not disdained by the mother moths. These, as a rule, deposit but one egg upon a leaf; rarely two appear to be laid upon the same leaf by a moth, in which case they are found close together, and were probably deposited simultaneously. Upon leaves marked for special observation I have had three eggs deposited during the same night. The number found upon a single leaf will depend upon the abundance of moths, the condition of the plants, &c. I have never observed more than seven unhatched eggs upon the same leaf. Eggs are laid during the first part of the night and early morning. I believe few are deposited between midnight and 2 o'clock a. m. In the period of incubation I found little variation; the young worms appeared on the fourth day, seventy-two to eighty-four hours from the laying of the egg, hatching usually in the early morning. The young worms appear upon the outer or upper leaves of the plant when nearly half grown.

Only green worms were seen until the fourth brood was well advanced, in the latter part of July. Worms with dark stripes then appeared, and gradually became more numerous, until at the close of the fourth and throughout the fifth brood they outnumbered the green worms. Numerous tests failed to show any difference in time of development between the two forms. The worms were seldom seen feeding at night, and only on bright moonlight or starlight nights. Many specimens were, however, bred from the egg to the moth in tight tin boxes, and this exclusion of light appeared to have no effect upon the coloration. Of those fed upon immature leaves a greater proportion remained uniformly green; but the experiment was not conclusive, as not a few of those fed upon mature leaves remained equally light-colored, while dark forms occurred in all my breeding-boxes. I was unable to find the worms feeding upon other plants than cotton, either in the cultivated fields or woods in the vicinity. Although I sometimes failed to observe more than three or four molts, a variation from the normal number, five, was never satisfactorily made out.

It is often asserted by the planters that cotton in the shade of trees is not eaten by the caterpillars. My own observations upon this point gave conflicting results. While in some cases I found cotton thus shaded entirely untouched, although the surrounding plants were much ragged, in other marked instances shade appeared to exercise no protective influence. The following transcript from my notes gives one case in point. It records the discovery of a brood center belonging to the fifth generation. August 20: I learned to-day of a portion of the field where caterpillars were to be found, and visited it. It is a small area of "bottom land," bordering upon the road. The cotton is somewhat ragged, and worms of all sizes are moderately abundant. There are worms just webbing up and pupæ both vacated and living. Young worms (one-third grown) are the most abundant, but eggs are scarce, and I saw but one or two moths. This is evidently a center of the brood following that in the "young cotton," which is in the same field about a quarter of a mile distant. By the side of the road, and covering a portion of this bottom, stands a very large oak tree, with low, spreading branches, casting quite a dense shade. The tree has been girdled and is slowly dying, but has not lost its leaves. The cotton rows under it are unbroken. The plants standing close about its trunk are very tall and rank, with large and fully

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matured leaves; they are covered with caterpillars, and even more badly ragged than those outside in the sun.

Cases of apparently whimsical exemption from attack are sometimes met with. As for example two fields, separated only by the turn of a furrow, one of which is eaten up to the last row and the other left untouched. In these, as well as in cases where shade is found to exercise a protective influence, I am inclined to suspect an explanation will be found, as has been suggested by others, in a difference in the nectar secretion of the leaf glands, the moths being perhaps attracted to those plants where the flow of nectar is greatest, and avoiding those where, from some cause, but little is secreted. As to the laws which govern the secretion of nectar I know nothing.

The period of larval existence was, at Centreville, about nine days in July and ten days in August. In vivaria in the house the time was extended to fourteen days in the former and sixteen days in the latter month. The worms occupy nearly the whole of one day in completing their webs or cocoons; the following day they change to pupæ, which attain their full brown color before morning of the third day.

The pupa, except in cases of accidental reversal, is invariably found with the head towards the base of the leaf. The pupa state lasts from eight to eleven days in July, from seven to eight days in August. The warm, damp nights in August seemed to hasten their development.

The moths begin to emerge from pupa soon after sunset, and continue to appear during a great part of the night. In August, on cloudy days, large numbers disclosed at 6.30 p. m. The period of existence in the imago stage is difficult to determine with certainty. The males probably die soon after copulation. In the fourth and fifth broods the life of the female is certainly not more than fifteen days. Under netting in the field, they survived nine or ten days, laying eggs nightly during at least half of this period, and dying without having deposited all their ova. I am inclined to think the average life of a moth in freedom is about ten days. In vivaria, when deprived of moisture, they invariably died in four or five days. By keeping the air in the breeding jar moist, and giving them fresh cotton leaves sprayed with water, their life was prolonged in some cases eleven days. They drank greedily, lapping up with their proboscis the artificial dew produced by an atomizer. I first observed copulation in my breeding jars on August 7. The following is a transcript from my notes of that date:

At 6 o'clock this morning I found two Aletia moths in copulation; they disclosed last evening from pupæ that I was handling. I watched them about fifteen minutes, when they quietly separated. The male genitals were not much protruded. The two terminal plumes clasped the body of the female on either side, but I was unable to observe the position of the other parts. The male rested with wings horizontal in the usual position, the female held the wings raised vertically, a position I have never seen it assume. Neither sex made any movement until they separated, when the male genitals were retracted at once to the normal position.

My next observation was on August 14, when I found two pairs in copulation at 4 a. m. On this occasion I watched my jars during the entire night, except between the hours of 2 and 4 a. m., when I unfortunately fell asleep. On awaking at 4 a. m., I found one pair in coitu in jar No. 9 and another pair in jar No. 11. Both contained moths which had emerged from pupa three nights before (August 11). Evidently copulation had been in progress some time, for they soon separated, when disturbed by the fluttering of the other moths. Both sexes held the wings horizontal. As to the position of the genitalia nothing new could be made out. Many fertile eggs had been deposited in the same jar earlier in the night, and probably by moths that had copulated during the first or second nights. My breeding jars have been under observation at all hours up to 1 a. m., but copulation was never seen during this part of the night. Up to August 14 my night work in the fields had never been continued later than 1 a. m., and consequently I had never seen copulation there. Subsequently I made observations during the early morning hours, and on several occasions found moths in coitu just before daybreak. The coupling ceased as soon as it became light.

During the day it is the invariable habit of the moth on alighting to turn the head downward. After dark and throughout the night, they retain indifferently any position they may happen to take on coming to rest. At dawn, as the light increases, it is a curious sight to see the moths, one after another, reverse their positions, and settle themselves for their diurnal nap. Aletia does not appear to me to be greatly attracted by light; on the contrary, the moths often seem to be repelled by it. In carrying a lantern through the fields at night, an occasional specimen flew against the glass, often, as it seemed to me, in anger. Multitudes, disturbed by the light, flew up at my approach and vanished in the darkness overhead. So wary do they become when a strong light falls upon them that observations of their habits by night are rendered exceedingly difficult, and I never once succeeded in watching closely a moth in the act of laying her eggs. Late in the season, when the moths roam far and wide in search of fruit, many fly into lighted rooms through the open windows, showing that for certain individuals light has some attraction.

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I believe also that a broad glare, like that of a bonfire, attracts a greater number than the concentrated light of a lantern. I have also known them to fly at the glowing end of a cigar.

That the moths are exceedingly fond of fruit, is a fact too well known to require iteration. I found them clustering upon figs, peaches, and especially upon persimmons, which attract them from great distances.

* * * * * * *

EXPERIMENTS WITH POISONS.

Pyrethrum.—Samples of the powder sent me by the Commission were of two sorts, Milco's Californian Buhach and an imported product. To test their relative strength, sixty Cotton Worms were collected and divided into two lots, as equally as possible, so that neither set should contain an undue proportion of old or of young worms. Each set was placed in a Mason jar, and thoroughly dusted with a small quantity of powder, one jar with the Buhach, the other with the imported pyrethrum. The worms were immediately afterwards turned out upon newspapers spread upon the ground. Those dusted with Buhach were paralyzed and unable to crawl about in from 15 to 20 minutes. Those treated with imported pyrethrum were similarly affected in from 25 to 30 minutes. In both lots the worms began to be affected in less than one minute, and nearly all died within 12 hours. Another experiment was made upon one hundred worms of all sizes, in which the powder (imported) was applied in the open air by means of a bellows. Worms one-fifth to one-third grown were completely paralyzed in 10 minutes; worms one-half grown in 30 to 45 minutes; full-grown worms showed the full effect of the poison after several hours. In about three hours the smaller worms appeared to be dead. The oldest worms did not die before night. Experiments were made in the field upon Aletia larvæ, using very small quantities of pyrethrum powder. A few particles dropped with the fingers upon worms from half to full grown produced convulsions in from 3 to 10 minutes. The action of the poison is much more powerful upon young than upon old worms, but depends in each case less upon the amount of powder used than upon the part of the body it first touches or the method of applying it. Very small particles placed upon the sides of the larvæ, especially near the anterior spiracles, produce a more marked effect than larger quantities dropped upon their backs or lodged among the hairs. The effect is also enhanced by driving the powder with force against them, by means of a bellows, for example, as the particles are thus driven into closer contact. The effect of Californian Buhach (pyrethrum) powder upon young Aletia larvæ is shown in the following experiments, the object being to ascertain the minimum quantity that could be used with effect:

All the larvæ were hatched last night (August 10), from eggs laid in breeding jar during the night of August 7 (except larva [*n*], which was only a few hours from the egg).

(*a*) Three minute fragments of pyrethrum laid upon back (terminal half of body) with the point of a needle: larva affected in 15 seconds; convulsed in 1 minute and 15 seconds. Died in p. m.

(*b*) One minute fragment applied on back (anterior segments): fragment dropped off in 3 minutes; probably only adhered to hairs of body 3½ minutes; larva appeared affected but slightly; after three hours larva appears to have recovered. P. m., went to eating and fully recovered. This is a very vigorous larva, probably several hours older than the rest. (August 12th; has grown larger, and eating well.)

(*c*) One almost microscopic fragment applied, with needle point, to side near spiracles: evidently affected in 15 seconds; convulsed in 1½ minutes. Fragment adhered one minute. Larva died in p. m.

(*d*) One very minute fragment (almost microscopic fragment) applied on side of body near middle. Larva lost sight of during 4 minutes, at end of which time was entirely convulsed. Died in p. m.

(*e*) Several (3 or 4) small fragments applied on side of body: affected in 30 seconds; convulsed after 2 minutes 15 seconds. Died in p. m.

(*f*) One minute fragment on middle of back: affected in 1 minute 15 seconds; convulsed in 3 minutes; fragment dropped off in 3 minutes. Four o'clock p. m., larva recovering; later, went to eating; entirely restored. (Aug. 12, alive and well.)

(*g*) One microscopic fragment on back at anal extremity of body and very soon lost off (20 seconds ?). Seemed affected after 5 minutes; examined after 2 hours, seems not injured. In p. m., entirely well [see (*g'*)].

(*h*) One large fragment (size of "blowfly" egg) applied for 5 or 6 seconds to side of body, near or upon spiracles: affected in 2 minutes; convulsed in 4 minutes; 2 hours, unable to move about; 4.30 p. m., still alive but disabled. Died before night.

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(*i*) One entirely microscopic fragment applied to back of neck: affected in 1¼ minutes; convulsed in 3 minutes; 4.30 p. m., appears recovering. (August 12, larva died this morning).

(*k*) One entirely microscopic fragment applied underneath anterior segments between legs: adhered only a few seconds; appears affected after 15 minutes, but able to move about. 4.30 p. m., recovering and eating; later, fully recovered. (August 12, alive and well.)

Note.—Larvæ (*l*) (*m*) and (*n*) were treated as follows: A small quantity of pyrethrum placed on a piece of paper was lightly sprayed with an atomizer, and allowed to remain covered with drops of moisture for about 10 minutes. The larvæ were then touched with a needle dipped in this poisoned dew.

(*l*) A single, very slight, and probably insufficient application beneath anterior segments: no moisture adhered to larva; affected after 1 minute 15 seconds; 1 hour later, appears torpid but not convulsed. 4 p. m., recovered and eating. (August 12, alive and well.)

(*m*) Touched with poisoned dew about anterior segments, and moisture left upon the back of the segments; more thoroughly applied than in preceding larva; affected in 45 seconds; convulsed in 2 minutes. 4.30 p. m., recovered. (August 12, alive and well.)

(*n*) A very young larva, probably hatched late this morning, was allowed to crawl along needle and over a drop of poisoned dew: instantly affected; convulsed in 15 seconds. Died in p. m.

(*g'*) Second experiment with larva (*g*) made in p. m. One fragment, size of blowfly egg, laid on back, middle of body, not touching the skin, but adhering to hairs; dropped off in 30 seconds; evidently affected in 45 seconds; completely convulsed in 2 minutes. Died in a few hours.

Pyrethrum powder was blown with a bellows upon Aletia moths clustering upon ripe figs at night. The moths were evidently affected, but flew away in a few minutes. No fresh moths alighted upon fruit thus dusted, but as the powder rapidly loses its strength when exposed to the air, the protection afforded by it to fruit probably lasts only a few hours, and it cannot therefore be recommended for this purpose.

Tried upon different insects, it appears to affect the higher Hymenoptera more than other insects. Ants are almost instantly affected. Wasps continue feeding for about twenty seconds, and are violently affected in from one to two minutes. Larvæ of all kinds are more quickly affected than imagos. Termites, owing probably to their tender bodies, are instantly affected and soon killed. Spiders resist longer than anything else. They sometimes change their skins when dusted with the powder. *Copris* and *Phanæus* are slightly affected, and long resist the action of the powder. *Scolopendridæ* affected similarly to spiders. Bugs slightly affected, especially the large and heavily armed predaceous species. Large grasshoppers slightly affected. Roaches very violently affected. These observations refer to the immediate action of the dry and undiluted powder, and are comparative only. There is no doubt that insects often recover from slight applications.

Experiments in the field, with the dry powder sifted upon the plants, gave very unsatisfactory results, unless large quantities of the powder were used. On August 28, a very windy day, I tried an application with the bellows, allowing the wind to carry the powder in fine clouds through the foliage, and using about one pound to the acre.

In this way, owing partly to the impossibility of securing an equal distribution, some worms were affected at a distance of ten or fifteen feet, while others, much nearer, were not affected at all. I have reason to believe that very few worms were killed outright at this trial. Some recovered in a few hours. A number of those which showed signs of pain, but had been very lightly dusted, I confined in vivaria, and all completed their transformation in the usual time. At the time the foregoing experiment was made, the leaves were quite wet with recent rain, and another heavy shower occurred later in the day.

Infusions made by pouring hot (not boiling) water upon the powder were found ineffective and quite worthless.

With a strong extract I have had no opportunity of experimenting. Alcohol poured upon the powder, extracts a sufficient quantity of the poisonous oil to be very effective when used with an atomizer, but is too expensive for use on a large scale.

London purple.—Several experiments were tried in which small quantities of this powder were dusted upon the plants without diluents. Whenever a quantity was used sufficient to kill the worms the leaves were badly scorched.

Poisoning the moths.—At a time when the moths swarmed at night about the fallen fruit under persimmon trees in the fields, I poisoned the fruit with London purple, and also with white arsenic. In this way many moths were undoubtedly killed, but as numbers of them flew away to die, the exact proportion could not be ascertained. Under nettings covering cotton plants, moths were readily killed by giving them poisoned fruit. They do not appear to dislike the fruit even when mixed with an excess of London purple or arsenic, and settle quite as readily upon the poisoned as upon

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the unpoisoned fruit. By poisoning the nectar glands moths were killed under nettings, but the result was not as satisfactory as with poisoned fruit. Although I do not think much practical benefit can be secured by attempts to kill the moths late in the season, yet, in view of its cheapness and effectiveness, baiting them with poisoned fruit seems preferable to any device in which lamps are used. Whether or not the moths of the early brood can be destroyed by poisoning dishes of fruit, as for example dried apples soaked, and exposed in the fields, I am not prepared to say, but I think it more likely to succeed than any of the lamp traps that have been recommended.

Yeast.—The results of experiments with yeast are: (1) in the field, yeast sprayed with an atomizer upon feeding larvæ, and sprinkled upon the leaves with a brush, had no effect during either dry or wet weather; (2) yeast poured upon pupæ in their webs, no effect, the moths subsequently disclosed; (3) in a very foul tin box in which frass, &c., had been allowed to accumulate, the worms neglected and in unhealthy condition, eleven caterpillars two-thirds grown were sprayed August 18 with yeast diluted with water to the thickness of milk; the diseased condition of the worms was immediately aggravated. Two died in twelve hours; August 20, three more had died; August 21, five worms alive, all unhealthy, but one webbing up; all finally died; (4) a tin box containing healthy larvæ, raised from the eggs, and ten days old, was thoroughly sprayed three or four days in succession, but box kept clean, fresh food and air supplied every day. All completed their metamorphoses, unaffected by the yeast: (5) three glass jars and several tin and wooden boxes containing healthy larvæ and pupæ of Aletia sprayed several times in succession, without any effect.

Early in the season it was my habit to freshen the air and contents of my breeding cages daily with pure water sprayed in by an atomizer. Late in August I found many of my boxes infected so that the contained insects died, or the contents became moldy after spraying with water, and I was obliged to abandon this practice. At this time, if yeast and water were used, the effect was simply to hasten the appearance of mold and the diseases of the insects confined in close boxes.

THE BOLL WORM (*Heliothis armigera*) Hübn.

I have often heard the statement made by planters that the Boll Worm did them more injury than the Cotton Worm (Aletia). I think, however, the amount of injury done is frequently exaggerated, the dropping of the squares and young bolls from many causes being often attributed to the attacks of Heliothis. During my season's work I nowhere found it abundant, although everywhere present. The life history of Heliothis having been thoroughly studied by Professor Riley and others, I did not give very much time to it. I found, however, that the eggs are laid singly, more often upon the leaf than upon the involucres of the flowers. They hatch in three to four days. The young worms feed at first upon the leaves, then upon petals of flowers, and finally upon the bolls. I, however, found comparatively few eating entirely into large bolls, and believe the worm sometimes eats only leaves and flower petals throughout its life. As before noted, they frequently devour the pupa of Aletia. In confinement the larval period lasted about twenty days, and the pupa twelve days.

The only parasites are *Trichogramma pretiosa* and a Tachinid fly which also preys upon Aletia and has already been noticed.

Very respecfully,

H. G. HUBBARD.

Prof. C. V. RILEY.

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APPENDIX II.

REPORT OF PROF. R. W. JONES.

OXFORD, *November* 27, 1880.

SIR: I herewith mail to you a brief report of work done by me and under my direction according to authority from you.

I had the valuable assistance of Prof. J. W. Kilpatrick, A. M., now of Central College, Mo., during August.

In gathering material and handling it for making the large number of extracts, infusions, and decoctions, which I tried here, and many of which I shipped, on your order, to Selma, Ala., to be used by yourself and Mr. Schwarz, I had the co-operation of Messrs. F. S. Chew and R. W. Jones, jr., both students of the university.

Accept my acknowledgments for your uniform courtesy in our correspondence and work, and be assured of my high appreciation of the valuable services you are rendering to the cotton interests of the Southern States.

Very respectfully, &c.,

R. W. JONES,
University of Mississippi.

Prof. C. V. RILEY, M. A., PH. D.,
Chief United States Entomological Commission.

THE COTTON BOLL WORM.

(*Heliothis armigera.*)

This worm is far more injurious to cotton in this part of Mississippi than the Cotton Army Worm or any other insect pest. I believe the cultivators of cotton are by no means aware of its devastating power. It begins its work here in May, sometimes in June, and continues until about the end of September. Its mode of work, and the great variety of its plant-food, give it marked advantages in the struggle for life and in multiplying. It is well known to all students of this subject that the moth of the Cotton Army Worm (*Aletia xylina*), in visiting a field of cotton, begins at a selected spot that affords moisture and tender, juicy plants, and lays its eggs within quite a limited area, so that the worms, as soon as hatching begins, are there in considerable numbers. This fact makes it comparatively easy and inexpensive to apply insect poisons for Aletia larvæ.

But the moth of Heliothis lays its eggs over a much wider area; the young worms are scattered more sparsely on the cotton, and therefore it is more costly and laborious to poison them. Moreover, during much of the time, these larvæ of Heliothis are hidden wholly or partially in the bolls into which they cut their way. It is difficult, therefore, to affect them by means of those poisons which must be projected upon the food of insects, and be devoured by them, in order to their destruction; and, no matter what kind of poison might be employed, a much larger quantity would be needed to reach the scattered Boll Worms than the same number of Aletia feeding close together.

It is not to be inferred that the damage in a field is small because the worms are scattered. The amount of damage done by a single worm is astonishing. I have counted 18 young bolls, shriveling, decaying, and falling or fallen, besides many blooms and unopened flower-buds pierced; all the work of one Boll Worm and that not grown.

I gave particular attention to two fields near Oxford this summer. I think the damage by the Boll Worm amounted to 25 per cent. of the crop. I visited a field with Judge Lawrence C. Johnson, of Holly Springs. Judge Johnson estimated the loss by Heliothis to be 20 per cent.; I thought his estimate a very moderate one.

Food-plants.—Besides cotton, this worm feeds on young corn plants, tender silks and grains of ears of corn, peas, beans, tomatoes, and okra. They may also feed on other plants on which I have not found them.

These worms are specially fond of the blades and tender stems of young corn plants

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and of the silks and grains of the growing ears. The presence of the worm on young corn plants is indicated by round holes cut in the blades, and the worm and its excrement may usually be found in the sheath. There is generally no external evidence of the worm on the ear; it eats the silk and tender grains at the distal end, and as it consumes the juicy grains it lies in the cavity thereby made, the excrement remaining behind it and between the husk and cob. In order to find the corn worm (*Heliothis armigera*) on the ear, it is, therefore, necessary to open the husk. I have found the worm grows more rapidly when it feeds on corn grains than on any other food, though the size of the worm at maturity is no larger, and I could not discover that the moth raised from the corn worm differed from other Heliothis moths more than those raised on cotton differed from each other. After these general remarks I will give the history of Heliothis as it was developed by my studies. It is proper to remark that my systematic work began about the middle of July, and even then my attention was for some time mainly directed to the preparation of vegetable extracts, infusions, and decoctions, in the hope of finding some plant or plants indigenous to this locality that possessed insecticide and insectifuge properties.

The egg.—It was very difficult to find the eggs. I never found, with the most careful search, more than two or three on a plant; sometimes not an egg on a plant.

The egg is white, clear white, with sometimes a yellowish or brownish coloration at the apex. It is fastened to the part of the plant on which it is deposited, very much as the egg of Aletia, by a gum. It is a little larger than the egg of the Cotton Worm Moth (Aletia), and sculptured very much in the same way.

I found them on the involucre of the flower or young boll, on the pedicel or flower stem, near the torus or receptacle, on leaves and on petioles or leaf stems. In the hot weather of July and August, the larger number of eggs was found on the under side of the thickest, darkest leaves. The duration of the egg state is from three to five days.

The larva.—The larva hatches and at first feeds on the tender parenchyma of involucre or leaf, and makes its way as quickly as possible to a flower or young boll.

In July and August the large majority of young Heliothis larvæ were found within the corolla, eating sometimes the essential elements of the flower and sometimes the petals. They seemed to be specially fond of these floral parts. While on the buds of flowers feeding they were quiet, but if seen on the leaf or stem they exhibited signs of restlessness and moved from point to point. Every flower bud and every flower attacked by them fails to produce fruit. The worm, when small, moves with great ease and with comparative rapidity, "looping" as it goes. As it grows larger its movements are less easy, and it is more liable, when disturbed, to fall from the plant. When a few days old, if bolls are on the cotton, it attacks these, seeming at first to prefer the small, tender bolls and afterwards the large ones. It bites off the outside slick, hard covering sufficient for a hole, allowing the entrance of the worm, and thereafter it feeds on the juices and seeds and cotton in the interior of the boll. Sometimes it cuts off a part of the outside of the boll in one, two, or three places without entering the interior, but this always insures the falling or rotting of the boll; the bite of the worm seems to be poisonous to buds, flowers, and bolls. The hole in the boll is often made between the boll and the calyx, so that the worm is concealed while at the work of perforation, though this is not always the case.

If a worm feed on a large boll and the excrement on the boll be exposed to rains, the coloring matter will be washed away and the fibers of cotton can be seen distinctly. I observed this for the first time on September 14; during the few days following before the disappearance of Heliothis, I saw numerous instances of it. The cellulose was unchanged by passing through the worm. In September I saw Heliothis feeding on cotton leaf in a field of cotton in which Aletia was abundant and where whole leaves were very rare; a good proportion of bolls was yet unopened.

I observed Heliothis on corn and on cotton at the same time and in different parts of the same field. The number of Heliothis did not seem to increase on cotton after the corn was matured.

Boll Worms eat each other. I have seen the statement that if two or more Boll Worms are started in a single package, even with a full supply of appropriate food, only one reaches the destination, and that if more than one larva is confined in a breeding cage one invariably devours the others. The latter statement I am prepared to contradict; repeatedly during the summer I had as many as three moths to issue about the same time in the same jar.

Boll Worms eat the chrysalids of Cotton Worms. I have seen them in the act, but I have never seen the larva of Heliothis eating the larva of Aletia.

The color of the Boll Worm varies greatly; when young it is slender and green, having a number of yellow and white bands and lines running longitudinally from the back of the head to the anal extremity; rarely these larvæ retain the green color throughout the larva state, but generally the color changes, as the worm grows, to yellowish or brown, the longitudinal lines and bands remaining; each segment of the body bears eight black spots, from each of which projects a stiff bristle. On the seg-

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ment these black spots are arranged in two rows; the spots of the front row are closer together on the back; those of the rear row extend down farther on the side.

Duration of the larva state from fifteen to twenty days.

Chrysalis.—The larva bores into the ground to assume the pupa state. In my breeding jars they went down two or three inches, the tube being oblique and open except a very slight covering at the top and some of them leaving the entrance uncovered.

I deem it unnecessary to give a description of the chrysalis, as you doubtless will do so from specimens at hand which you will accompany with accurate drawings.

The fact that the chrysalis of the Boll Worm is under ground will prevent any one from confounding it with the chrysalis of the Cotton Worm.

On the Boll Worm chrysalis there is much more of a yellowish cast and more luster. The time during which the pupae remained in ground ranged from eleven to sixteen days.

The whole time, therefore, elapsing between the laying of the egg and the appearance of the moth from it is from thirty to forty days.

The moth.—The habits are very much like the moth of Aletia; it is larger, measuring as much as 1⅛ inches across the wings, and the largest being 1⅜ inch long. It begins to fly soon after sunset. I have watched it a great deal, but never saw it on any flowers or leaves except those of cotton. It would often alight in the grass. It feeds on the nectar of cotton. I put out lights in the cotton during part of the summer; some were attracted and killed, but the success was not such as I expected.

I have not seen the moth of Heliothis since the cold rainy weather about the last of September. The thermometer early in the morning for several days was down to 40° Fahrenheit.

I have searched diligently without finding one.

Weather.—Warm, damp weather favors the multiplication of Heliothis. In dry weather, when it was very warm, I have seen the worm dead on the bolls without having apparently suffered any violence; the circumstances were such that I inferred it died of heat and lack of moisture.

The larvæ of Heliothis are very quickly affected by cold rains. During the rains previously referred to, occurring at intervals from September 10 to 30, though the temperature was by no means low enough for frost, I found larvæ of Heliothis in the bolls in a state of torpor, and in some instances they were dead. They are very sensitive to cool rains. In many cases throughout the season I found bolls which had been pierced more or less by Boll Worms, occupied by white footless grubs of a fly. The fly deposits its egg in the decaying contents of the boll that has been abandoned by the worm. These eggs hatch and the maggots feed on the putrefying matter. I have seen some persons who supposed that the maggots *caused* the rotting of the boll and that the fly injured the boll in oviposition. This cannot be true. The boll rots because of the injury from the Boll Worm, and the decaying boll invites the fly.

Natural enemies.—These (so far as I have been able to ascertain) are the same as those mentioned in your Bulletin No. 3, which attack Aletia.

I have observed the following enemies:

Birds: Swallows, Bee Martin, King Bird, Bluebird.

Insects: Spiders, larvæ of Lady Bird, *Acanthocephala femorata*, Wheel Bug, Soldier Bug, Tiger Beetle. Bats catch many moths.

Parasites: In the latter part of the season a great many larvæ of Heliothis and Aletia bore a white egg, which was found to be that of a Tachina. In some instances the moths hatched out notwithstanding the egg of the parasite. In other cases the chrysalis was destroyed by the grub; the latter was generally the case.

Sometimes as many as five eggs of Tachina would be found on one larva of Heliothis or Aletia—more generally on Aletia than Heliothis. This Tachina must be an exceedingly formidable enemy of both Aletia and Heliothis.

Much has been said of the destruction of Heliothis by Ants. I have never seen Ants eating them in any state until they had been killed or injured by some other agent or had died, except when the worms were confined in jars; even this was a very rare occurrence. I think I observed it but twice, and both these instances were at my residence; no instance occurred in the laboratory where my work was done.

Before proceeding to give an account of the vegetable preparations which I made and my experiments with them, I will make a few observations on the

COTTON ARMY WORM.

(*Aletia xylina.*)

I will not refer to any facts coming under my notice that are contained in your Bulletin No. 3.

After a protracted season of cloudy days and frequent rains with a warm wind from the South, we found Aletia, September 11, in a field near here; the locality in the field was *identically the same* as that in which you found them October, 1879. From that locality they gradually spread over the greater part of the field of 20 acres in cotton.

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The number of moths from the first brood of worms was very large; they were not appreciably diminished by any enemies. The principal resting place by day was a part of the field in which the grass was thick and overlapped the middle of the rows; by night these went over well nigh the whole field, depositing eggs mostly on the large, full grown leaves about one-third the height of the plant from the ground. Of the next brood of worms a large proportion bore eggs of the Tachina fly, the maggot from which destroyed a great many chrysalids; specimens of larvæ bearing Tachina eggs I forwarded to you. Whilst the moths were so abundant I put out in the fields some pans containing poisoned sweets as follows:

(1) Molasses and vinegar and white arsenic.
(2) Molasses and vinegar and corrosive sublimate.
(3) Molasses and vinegar and potassium cyanide.
(4) Molasses and vinegar and copper sulphate.
(5) Molasses and vinegar and strychnine.

In some cases I substituted for vinegar alcohol and water.

I did not succeed in destroying many. The fluid in the pan was covered by a perforated top. In this way the greatest effect was by molasses, vinegar, and white arsenic.

But I destroyed a larger number by using open pans containing thick molasses with a little vinegar; the moths were caught by the molasses.

I noticed Aletia moths on flowers of Solidago or golden rod, which blooms here in September. I saw frequently the chrysalids of Aletia enveloped in the leaves of Morning Glory; but never saw the larvæ feeding on that plant. On October 13 and 14 the weather began to grow cool; the wind blew from the northward; it was not by any means cold enough for frost; during this wind I observed Aletia moths moving southward, leaving the cotton field and entering the wooded land lying south of the field. They frequently alighted on the oak leaves and remained a long time. They did not move in numbers together, but singly. I saw no eggs deposited on the oak leaves.

On night of October 15 a cold rain fell, and by the afternoon of the 16th the greater part of the moths disappeared; late that afternoon I looked carefully for them where they had been so abundant in the grass and found but a few; those that remained were to a great degree benumbed and their movements much impaired. Larvæ were still on the plants; they, too, were affected by the cold.

The three or four days succeeding were somewhat warmer, though the nights continued cool, the thermometer being in the early morning as low as 41° F. Then the moths showed themselves more, but not a fifth of the number that were in the field prior to the 15th. I think a large proportion of these last issued from pupæ during the warm days.

On October 23 I visited the field after a considerable frost; found the larvæ still living, and leaving the upper frosted leaves for lower ones that had been sheltered; many larvæ fell, and were eaten by spiders and beetles. Several days later many worms and chrysalids fell and were eaten by hogs which searched the whole field. I searched in the grass and found some moths, almost in a state of torpor, scarcely able to move; others had been devoured, as I knew from the wings found and from the partially consumed bodies of some. I reared many Aletia larvæ and kept many chrysalids for transformation.

One was only *five days* a chrysalis, becoming a moth on the sixth day.

VEGETABLE PREPARATIONS.

I will now proceed to mention the vegetable preparations which I made in the hope of finding some indigenous plant possessing effectual insecticide properties. In every case, I used the plants or parts of plant after carefully drying them in the shade.

(1) Ailanthus (Tree of Paradise): Made decoction three-fourths pound leaves to 2½ gallons water; infusion, 1 pound leaves to 2½ gallons of water.

(2) Pokeweed (Phytolacca): Decoction, 8 ounces leaves to 1 gallon water; infusion, 8 ounces to 1 gallon water. Pokeweed root: extract, 2 ounces dried root to 1 gallon of mixture of alcohol and water in equal parts.

(3) Ragweed (Ambrosia): Decoction, 1 pound of stems and leaves to 1 gallon water. Infusion, as above, 8 ounces to one-half gallon alcohol and one-half gallon water mixed.

(4) *Helenium autumnale:* 1 pound to 2½ gallons water. Decoction and infusion.

(5) *Helenium tenuifolium:* 1 pound to 2½ gallons water. Decoction and infusion.

(6) Pennyroyal: 2 ounces to gallon of alcohol and water mixed. Extract, 2 pounds to gallon water. Decoction and infusion.

(7) *Datura stramonium* (Jamestown weed): Seed dried and ground. 8 ounces to quart of alcohol.

(8) Mock orange (*Prunus caroliniana*): 4 ounces leaves to quart of water. Decoction.

(9) Yeast ferment.

(10) Buckeye (Æsculus) fruit. Extract.

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All the foregoing I used frequently and freely diluted with varying quantities of water. None of them injured the worms, either on cotton (Heliothis and Aletia) or those on cabbage, ruta bagas, &c.

I made a decoction of China leaves and small twigs. This I sprayed freely on the cotton plants, and I think it had a large effect in preventing the moths of Heliothis and Aletia from ovipositing; but it did not destroy the larvæ. The alcoholic extract of the China berries and leaves, adulterated with twice its quantity of water, was sprayed on twelve Aletia larvæ, full grown. Most of them fell to the ground, and *four died.* This experiment was repeated several times, with about the same result; but when the extract was diluted with ten parts of water it failed to bring the worms to the ground. I concluded from this fact that the cost of the alcohol would be so great as to prevent the use of this preparation.

I made a decoction of elder (*Sambucus canadensis*), using the leaves, small twigs, and berries; also an infusion of the same. This, projected in spray on Aletia, Heliothis, and on the worms infesting cabbage, caused them to cease eating, and in several instances caused them to abandon the plant, whether cotton or cabbage. It is well known that in all such cases the cotton worm is much more likely to be devoured by predaceous insects than it is to reascend the plant.

Pyrethrum.—As an insecticide this is superior, incomparably superior, to all other substances with which I have experimented. I used it in powder diluted with wheat flour, and as an extract variously diluted with water. The success attending my experiments with this were eminently gratifying and satisfactory.

It may be proper to remark that I used the pyrethrum (Buhach) raised by G. N. Milco, of Stockton, Cal., some sent me from the headquarters of the U. S. Entomological Commission under the name of "Caucasian Insect Powder," and some which I purchased of Messrs. Bullock & Crenshaw, Philadelphia, Pa., as "Persian Insect Powder."

When used in the state of dry powder, that of Milco seemed to have a considerable advantage, but the others seemed to be quite equal to it in the power to yield deadly extracts.

Mode of preparing powder: 1 part of pyrethrum to 20 parts of wheat-flour, thoroughly mixed and shut up in a tight tin box for twenty-four hours. This blown by bellows proved very efficient in destroying Aletia and cabbage worms which it touched. It did not kill squash bugs, though it drove them for the time from the plants. It killed the Boll Worms upon which it was projected, but did not disturb those that were concealed within the bolls.

Extracts: A. Made with common (ethyl) alcohol 95 per cent. B. Made with methyl alcohol (wood spirit).

In all my first preparations I proceeded as follows:

I introduced into a glass flask about 4 ounces of insect powder and added about half a gallon of alcohol, corked and allowed to stand for twenty-four hours. I then perforated the cork and introduced a glass tube, one fourth of an inch in diameter and 36 inches long; then subjected the flask to the well regulated heat of a water bath, not allowing the temperature to reach the boiling point of alcohol. I usually applied this gentle heat for about five hours, then set aside to cool. At first I decanted the extract from the residue, and before using, diluted with water, as shown in the experiments mentioned farther on. Subsequently, I shook up the solid residue of the insect powder with the extract and diluted the whole with water, and in applying kept the solid matter suspended by agitation. I found the latter plan economical. The residue being wet with alcohol, readily spreads throughout the water and evidently adds something to the value of the extract.

I have never seen any statement or suggestion in regard to the use of wood spirit as the menstruum. It occurred to me to try it. I found it to be a quicker solvent of the essential oil and coloring matter of pyrethrum powder than common 95 per cent. alcohol. I find that 1 pint and 2 ounces (by measure) of wood spirit will extract all the useful material out of an ounce of pyrethrum. Good wood spirits can be bought for $1.25 per gallon. The extract made with wood spirit will bear dilution with a somewhat larger quantity of water than the extract made with ethyl alcohol.

On this point I state my results thus: One pound pyrethrum powder to 20 pints (2½ gallons) wood spirits. This can be safely diluted in the earlier part of the season when the worms are small with forty parts of water. Hence one pound pyrethrum and 2½ gallons methyl alcohol will when diluted make 100 gallons of liquid for the destruction of insects. Allowing 40 gallons to the acre, the cost of this insecticide would be $1.50. With improved atomizers this will be lessened.

Wood spirit is more volatile than ethyl alcohol. This, I think, gives it considerable advantage over ethyl alcohol as the solvent for the essential oil of the pyrethrum, when the extract is to be used for Boll Worms that are working on the contents of bolls. By its ready volatilization it distributes the insecticide rapidly into the adjacent air, and when not directly thrown into the hole cut by the Boll Worm it is car-

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ried into the chamber by rapid diffusion, and, affecting the worm, causes it to come forth from its concealment upon the moistened parts of the plant, where, by the contact of the liquid, it is poisoned to death. The extract made with ethyl alcohol is also volatile and produces this same effect, though in a less degree to the extent that its volatility is less than that of methyl alcohol.

The extractive power of methyl alcohol on pyrethrum is so great that it is hardly necessary to apply any heat; the alcohol may be allowed to stand twenty-four hours on the powder, being shaken up a few times and then the whole, *i. e.*, both the extract and the solid residue, may be mixed with water, so as to give 100 gallons to the pound of pyrethrum.

I found that the use of the liquid is much to be preferred to the powder. It reaches all parts of the plant better; it is more easily handled and it kills quicker.

EXPERIMENTS.

1. Sprinkled powder on half dozen Heliothis in cotton blooms in the field.

In a few minutes they left the blooms, crawled upon the leaves, fell to the ground and attempted to crawl off; before going far they stopped and rolled over, as if in pain, then crawled a little farther with further rolling and twisting. After some hours, they were considerably shrunken, and became of a light yellow color instead of green. I observed these until night; when I left none were dead; next morning, none of them could be found. From this single experiment, I would not have known whether the worms died and were devoured by other insects during the night, or whether they recovered and made their escape; but subsequent experiments satisfied me they must have died.

2. I tried a similar experiment on Heliothis, which I brought into the laboratory, putting them in blooms and on leaves in such manner as to supply the natural conditions. I applied the powder as above at 11 o'clock a. m. They were affected as those in experiment (1,) except that they seemed to be more violently attacked. They were not dead late in the afternoon; they were all dead next morning, the size of the worms when dead being less than half their size before the application of pyrethrum.

In these experiments, I was careful that some of the powder fell on each worm. Of course, this would not be the case in ordinary field-work. My object was to see if, when fairly applied, powder of this strength would kill insects.

I found that insects with a thick chitinous covering frequently flew away, not seeming to be seriously affected.

I tried this powder on Cabbage Worms; it kills them when it touches them; but on cabbages the worms are so well protected by the width and arrangement of the leaves that many escaped.

It did not protect the cabbage plants, except for a short time, from the flea beetle.

3. August 27 I sprinkled extract pyrethrum, 1 part alcoholic (ethyl) extract to 20 parts of water, on a cotton plant where there were three Boll Worms. One of these had penetrated a boll so far that only a small part was extended outside the boll; other two were on the flowers. In five minutes the worms were rolling and twisting, falling to the ground; died in a few hours.

August 30. Used same extract as above on three Boll Worms. Result substantially same so far as Heliothis was concerned. Two young grasshoppers were quickly killed, and a lady bird fell to the ground. It was not dead, but struggling, as if in pain, when night came on; had disappeared next morning.

4. September 17: In the following experiment I used some of the same extract spoken of in preceding experiment. The quantity this time was half pint extract to five pints water. I selected a spot in the cotton-field where Aletiæ were tolerably numerous. There were three stalks of cotton growing close together, and the vines of morning glory had densely intertwined themselves with these three plants, making the foliage very thick and hard to penetrate. I caught a number of Aletiæ from other stalks of cotton and put them on these until I could count 120. In all this time neither I nor either of the gentlemen present to witness the experiment noticed a boll worm (Heliothis). I used a small fountain pump made by Rumsey & Co., Seneca Falls, N. Y. We sprayed the diluted extract over three rows for about 20 feet, throwing more upon the three plants mentioned than elsewhere. Whilst the spray was falling upon this thick foliage I closely watched its effect; to my surprise a large Heliothis appeared on a leaf, seeming to be bewildered and making rapid exertions to get off. On examination I found it had come from the interior of a full-grown boll on which it was feeding; the orifice it had cut was on the upper side, and I suppose some of the fine spray passed through the orifice, and disturbing it in its excavations, caused it to come forth. Soon after it appeared it crawled on a leaf which had been slightly wetted with the extract, and in two minutes from the time the extract was thrown on the plants this Heliothis fell to the ground, and after convulsions, rolling, crawling, twisting, which lasted an hour and a quarter, it died. In four minutes about

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half of the Aletiæ had fallen to the ground and were in convulsions, the younger worms falling first. At the end of one hour there were but four larvæ of Aletia on the cotton that had been reached by the extract, and these were evidently much affected by it. Next morning I found only one Aletia larva alive on these plants.

I took seven chrysalids of Aletia from these plants that received the spray, and also at the same time took other chrysalids from a part of field not reached by the spray.

Only one of the first lot of chrysalids showed signs of life afterward, and it died in the effort to extricate itself from the pupa-covering. The other lot of chrysalids treated similarly in a jar produced moths.

5. On Cabbage Worms.

(a) Twenty-two worms, some *Pionea rimosalis*, some *Pieris oleracea*. Extract pyrethrum in methyl alcohol. Strength of liquid: 1 part extract to 30 parts of water. Every worm killed in a few minutes.

(b) Twenty worms as above, three green, the others *Pionea rimosalis*. Extract pyrethrum in common alcohol. Strength: 1 of extract to 30 of water. In four minutes worms were all dead but *four*; three Pionea escaped, and one Pieris. The small worms were killed first in both experiments, as I found to be almost invariably the case with Aletia and Heliothis.

6. September 21, on Boll Worms.

Foliage so dense as to afford the best possible protection. Extract of pyrethrum in methyl alcohol. Strength: 1 to 32 of water. Three of these worms were three-fourths of their lengths in the bolls, the fourth was entirely concealed. I threw a very small quantity of the liquid on this cotton; for three or four minutes there was no movement of the worms, but presently they came forth suddenly from the bolls, began to crawl uneasily on the leaves and stems, soon fell to the ground, and in one hour and four minutes three were so nearly dead as to make it certain they would die; one crawled off, showing some signs of paralysis. Not having time to wait in order to ascertain if it would die, I sprinkled a small quantity of the same liquid on it; then its crawling quickly ceased. All these were large larvæ.

7. September 28. Extract pyrethrum in methyl alcohol. Strength: 1 part extract to 40 of water. Sprayed liquid at 10.45 a. m. on a very large number of worms (Aletia), covering a considerable area. All the small worms were killed in an hour. Nearly all the large larvæ fell to the ground, but many of these succeeded in crawling away, and some ascended the plants, while others of the same size died in convulsions.

Many other experiments were made by me, but nothing was developed not included in those cited above.

I have the honor to be, very respectfully, &c.,

R. W. JONES,
Special Agent, U. S. E. C., Oxford, Miss.

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APPENDIX III.

REPORT OF J. P. STELLE.

SIR: I have the honor to submit the following report of my experiments and observations as a special agent of the United States Entomological Commission engaged in the work of investigating cotton insects under your direction:

Having been assigned to duty in the State of Texas, I first established my headquarters at Calvert, in Robertson County, a point in the rich cotton-producing regions of the Brazos Valley, exactly on the line of 31° north latitude. It has usually been understood that the Cotton Worm makes its first appearance for the season in Texas in the most southern counties where cotton is grown, but for this year the rule does not seem to have held good, as it appeared in injurious numbers in Robertson County as early as at any other place in the State. Information of its early appearance in this section influenced me in making choice of my location, and it eventually turned out a most fortunate choice, on account of being entirely above the line of the heavy rains which visited Texas in the course of the summer. While the counties along the Lower Brazos and Colorado were being drenched with rains daily, Robertson County was entirely exempt; in fact, scarcely a drop of rain fell in this region between the 1st of July and the 1st of September, a circumstance greatly favoring my field-work, as will be readily seen.

Both the Cotton Worm (*Aletia xylina*) and the Boll Worm (*Heliothis armigera*) appeared on the lowland farms along the Brazos, in what planters would term injurious numbers, about the 20th of July. The weather was quite warm at this time, and it continued warm throughout the season, the thermometer usually marking from 90° to 95° Fahrenheit at 2 o'clock in the afternoon. This, with a gentle breeze from the south, bringing up an atmosphere from the rain-belt, heavily charged with moisture, seemed to give every condition favorable for a thrifty growth and quick transformation of the insects. As a consequence brood succeeded brood with astonishing rapidity, the worms spreading quickly to the uplands, and doing their work so effectually that by the 1st of September all the cotton fields where remedies had not been applied were completely stripped of their leaves, with a very large per centum of the bolls bored into. This cut short my operations at Calvert, and in order that I still might have more time for field-work, I changed my location to San Marcos, in Hays County, where the worms were then (September 1) just beginning to put in an injurious appearance. Here I remained till the 15th of October, prosecuting my labors under conditions reasonably favorable in every respect.

Summing up the results of my investigations as secured in the lines laid down for the government of my work, I may begin with what planters in many parts of the South call

COTTON BLIGHT.

In some localities it is known as "stalk-rust," and in others as "root-rot," but cotton blight seems to be the name by which it is most generally called in Texas, and I think the same may be said for a majority of the other Cotton States.

This trouble begins in the cotton field about with the earliest appearance of blooms, and usually on uplands, though one occasionally meets with it in bottom plantations. The first indication we have of its presence is a sudden wilting of the plants, which, up to this time, were to all appearances as healthy and vigorous as any in the field. In the morning the plants are looking all right; in the evening their leaves are seen to be wilting; to-morrow evening they are blackened and dry. Usually the earliest attack is made upon only a few plants in a place, more commonly than otherwise upon a single specimen. A week later, perhaps, and one of its nearest neighbors shows symptoms of the blight, then another and another on till frost cuts short the growth of the crop, when, in many cases, it will be seen that all the plants of a spot several rods in extent have been ruinously blighted. The bolls that are at maturity when the plant dies will open and show no particular damage, but the young bolls will dry up and be lost.

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There are many theories with reference to the cause of cotton blight, some attributing it to a fungoid growth, others to a peculiar poison in the soil, and still others to the work of insects. This last-named theory carried it to the attention of the Commission, and led me to make a careful study of the phenomenon. On taking up the plants, even at the first indication of wilting, I found all the rootlets completely dead and usually rotted, and the main or tap root dead, with the bark ready to slip off and the pith blackened. I found numbers of adjacent plants, showing no sign of blight above ground, that were more or less affected in the roots. In a majority of these cases many of the rootlets were already dead and decaying, while the disease had not yet reached the main root. In some instances half the main root was dead, while the other half, with its attached rootlets, was living and performing its natural functions. To some of these I carefully returned the soil without particular disturbance, not having unearthed the rootlets beyond an inch from the main root, and not having unearthed the side of the main root more than three or four inches below the surface. In no such cases did the plants recover; they all died a few days later, and an immediate examination revealed the fact that in the space of time named the rot had extended to the healthy side of the root and rootlets. I further found that the first attack was made on the very extremities of the rootlets farthest from the main root, and usually on those deep down in the ground. From these extremities it passed gradually to the main root. When it had reached and surrounded the latter the leaves of the plant invariably wilted, as already mentioned. I saw not a single instance of the recovery of a plant after the leaves had begun to wilt from the effect of this blight.

A most thorough study of cotton blight, made from time to time throughout the season, has entirely convinced me that insects have nothing to do with it whatever. This, of course, if I am correct (and I think I am), places it outside the scope of the United States Entomological Commission. I found no insects associated with it in any way that could be considered so much as even slightly suspicious. Nothing unusual was ever found upon the plant above ground, and the insects found in the large quantities of earth that I examined, as taken from about the affected roots, were also found in equal numbers about the roots of healthy plants in portions of the fields where no blight had ever appeared. The microscope revealed to me a fungoid growth upon the decaying roots and rootlets, but I was not able to make sure that this was otherwise than the result rather than the cause of the blight. I found the same fungus upon other decaying vegetation, while I could detect no trace of it on cotton roots in health, nor even in their earliest stages of blight.

I trust I shall be excused if I here venture a step beyond what I consider the province of the Commission to state that cotton blight, once started, appears in succeeding years upon the same spots; usually upon the highest and best drained lands of the field. I was often told that any other crop than cotton planted upon the same spots would be likewise blighted, but this I subsequently found to be a mistake. Rotation for a few years in other kinds of crops destroys it, so that when cotton comes back to the same field blight is not apt to appear for a year or so at least; and when it does appear there is no certainty that it will appear in the old spots. This points to the fact that it is something peculiar to cotton, and to the further fact that, be the cause what it may, rotation of crops is the remedy.

BOLL ROT.

This is another phenomenon which has been greatly puzzling the cotton-planter and his friends up to the present time, and giving rise, as such things usually do, to any number of theories. It consists in the rotting of the interior of the boll after it has attained nearly or quite to full size. In some cases the entire contents, both lint and seed, become a fermented and putrid mass, bursting the boll and running out frothing over the exterior, presenting a most disgusting spectacle. In other cases the contents of but one or two divisions in the boll go into putrefaction, leaving the remainder to mature and open out an inferior grade of cotton; though this is the exception rather than the rule. Usually when the rot takes hold of a boll all its contents are totally lost.

The first indication of boll rot is a bruised or greasy-looking circular spot about one-fourth of an inch in diameter on the outer covering of the boll. As this spot grows in age it changes gradually from its original dull green to a dark brown color, after which, if the boll has not already burst, as a result of internal fermentation, it will, if opened, be found to contain only the disagreeably-looking mass already described. If found already burst, an examination will be apt to show its interior literally working with small worms, the larvæ of insects that, attracted by the matter oozing from its ruptured seams, have made use of it as a nidus in which to hatch and rear their young.

In times past these little worms, simply a result, and not at all connected with the cause, have been charged with the authorship of this boll rot mischief, but I had the

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good fortune to make a discovery which lets them out of the hands of the court without bail. I was amusing myself one evening trying to induce a colony of ants to replenish their larder with a well-grown Boll Worm (*Heliothis armigera*), but they didn't seem to want him, so he made his way to the nearest cotton stalk and ascended. I kept quiet to see what he would do. Just as the sun was setting he reached a cotton boll bordering upon maturity, and fell to work at it after the usual manner of Boll Worms. Its shell proved too hard for his boring machinery at the point where first attacked, therefore he changed his location to the other side and tried it again. Same result; then he took himself to another part of the plant and set to work upon another boll. While this was going on I thought I would examine his first job to see if he had left any mark upon the surface, when lo! to my great surprise, I saw the identical dull green or bruised spot always taken as an indication of coming boll rot; and on the opposite side of the boll where he had worked was another. There could be no mistake about it. I watched his operations till the gathering darkness concealed them from view, and until he had made eight similar bruises. Tearing my pocket-handkerchief into strips and tying them as marks at the base of the bruised bolls, I left him alone in his glory.

Next day, towards evening, I found the bruises already assuming a brownish hue; in three days more they were dark-brown. On the fifth day the bolls began to burst; not one upon which I had seen the Boll Worm work that evening escaped entire destruction by the "rot."

With the back of my pocket-knife I made similar bruises on other bolls to see whether or not the effect would be the same; but it was not—from *my* bruises the interior of the boll sustained no injury whatever.

Since, on two occasions, I have seen the Boll Worm making these same bruises, and have kept the bolls under mark till they rotted, which they did in every case; all of which convinces me that I have found the cause of boll rot, but how the mere nibbling of a worm upon the surface of the boll brings it about is more than I shall attempt to explain.

THE FLARE.

The involucre or "square" which surrounds the base of the cotton-flower bud, or young boll, is found to have spread out, exposing to view a kind of neck or stem below the bud or boll. This condition planters call the "Flare." Upon close examination of a specimen we discover that a small hole has been bored into the bud or young boll, and that the castings of some insect are deposited upon the involucre just below it. Or, if we do not find these, we, upon still closer scrutiny, discover that the "neck" of the bud or boll exhibits a puncture or two so minute as to be scarcely visible to the naked eye. In a short time this injured fruit separates from the plant and falls to the ground.

The question as to the cause of Flare has been settled in case of the holes bored in the flower-bud or young boll; it is the work of young Boll Worms; but in the case of the minute punctures the author, so far as I know, has not yet been identified. In obedience to instructions I made diligent search for the culprit throughout the season, but was unable to detect him directly at the work, though I often saw certain Hemipterous insects (as leaf hoppers) in such familiar juxtaposition to young cotton bolls or flower-buds as to strongly rouse the suspicion that they knew more about the cause of Flare than was known to me. They are a class of insects so shy as not easily to be detected at mischief. I tried the experiment of confining some of them under gauze cloth with young squares, but secured no results. It is, in my opinion, highly probable that several species of Hemiptera may have a hand in producing the "Flare."

OTHER FOOD PLANTS THAN COTTON.

The woods and prairies adjacent to cotton-fields were often carefully searched in hopes of finding the larva of Aletia feeding upon some other plant than cotton, but to me no such "find" ever resulted.

Repeated efforts to feed the worms in confinement upon such botanical relatives of the cotton as could be found native to Texas were also made. Many species of Malvaceæ were largely experimented upon in this direction, but, save in one instance, there was gained not so much as a single step towards success. That instance was in the case of *Abutilon texensis*, the worms having eaten part of one leaf. Beyond this they fed no more, though fresh and tender plants were placed at their disposal every day; they either "webbed up" or starved to death, depending upon their stage of growth when put into confinement.

With reference to Aletia in the moth state I observed the case to be quite different. The moths seem to find their natural food upon almost every species of plant yielding nectar. Among the cultivated plants outside of cotton the Southern field pea (*Dolichos*) appears to rank as a great favorite. On several occasions, where patches of

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this pea were adjacent to the cotton-field, I noticed the moths flitting about it in great numbers at night, and in evening twilight they were to be seen passing in swarms, as it were, from the cotton to the peas. I also saw moths of the Boll Worm feeding in the pea patches with large representation.

Unlike the larva of Aletia that of Heliothis (Boll Worm) appears to be an insect of wide range so far as relates to its natural food. While it feeds upon the bolls of cotton with evident relish, thus leading us to call it *the* Boll Worm, cotton bolls do not appear to be its first choice by any means. It evidently has a decided preference for green corn, upon which it multiplies with greater thrift than upon any other cultivated crop. I think that, of all the Cotton States, the Boll Worm does most damage to cotton in Texas, growing, I suppose, out of the fact that Texas raises the most corn. In all my observations I found the rule to hold good that where fields of early corn were adjacent to cotton the cotton crop sustained greater damage from Boll Worm than where they were not. This, according to my reasoning, is because the early broods of Boll Worms are advantageously raised upon the early corn, which eventually becoming too dry and hard for their purpose forces the insects to emigrate to the cotton fields for a propagation in later broods.

ANNOYANCES TO THE COTTON WORM.

I find it a thing by no means rare for planters to become suddenly carried away with the idea that they have just discovered complete remedies for the Cotton Worm, and for large districts to become considerably electrified over the discovery, when, in truth, the new remedies are nothing more than temporary annoyances thrown in the way of the insect and its work, and consequently worth very little indeed, if anything. Among the latest of these may be listed an application to the plants of a solution of

Common salt.—Soon after reaching Texas I heard that the planters in certain localities of the State were effectually saving their crops from worms by sprinkling the plants with "brine," and it even got into the papers and took a general run all over the country, producing quite a commotion. Now, I had no faith whatever in salt as an insecticide, still, as the thing met me at every hand, I concluded to put it to the test. My applications were made with salt in solution; No. 1 had two ounces of salt to the gallon of water, and No 2 three ounces of salt to the gallon. These solutions were thoroughly sprinkled over plants upon which Cotton Worms were at work in large numbers. Two days after the applications had been made I thought there were fewer worms on the plants sprinkled with No. 1 than before, while there was an undoubted thinning out under the effect of No. 2. The leaves sprinkled with solution No. 2 were considerably scorched by the salt. No dead worms were found; indeed the salt had been to them nothing more than a temporary annoyance, causing them to move to the adjacent plants not salted—I saw them going in considerable numbers. And the protection was only for a very brief season; a few days later, when food became more scarce on the adjacent plants, those to which the applications had been made were restocked with worms and speedily stripped of their leaves.

Saltpeter.—This salt (nitrate of potassa) also got into the papers upon the authority of some planter as a never-failing remedy for the Cotton Worm. He applied it in solution made by dissolving an ounce of the salt to the gallon of water. I put it to careful test, following his directions, and found it, like common salt (chloride of sodium), to be simply a temporary annoyance to the worms, and nothing more.

Road dust.—A much traveled road ran east and west through one of the fields in which I was conducting my experiments. Early in the season the cotton on the south side of this road was badly damaged by the Cotton Worm, while for 40 feet along the northern side it had not been much disturbed. Investigation for the cause of the exemption showed it to arise from dust blown over the plants from the road by a prevailing wind from the south. The discovery seemed of value as a suggestion of the idea that a dry season, with strong winds blowing dust over the plants, may make an unfavorable condition for the growth and multiplication of the Cotton Worm. It is this possibly that has given rise to the notion that a dry season is less favorable for worms than a wet one. Although dry in Central Texas this season, there were no strong winds, not enough to carry dust from a road save in cases where it had first been stirred up by some other cause, as a passing vehicle, for instance.

But in the case just mentioned the dust proved only a temporary annoyance to the insects; later in the season the exempted cotton was entirely stripped by them.

Open spaces.—It is noticeable that cotton plants growing immediately upon the border of open spaces, as along the sides of roads, or adjacent to crops of lower growth, &c., are exempt from an attack by the worms longer than those growing in other parts of the field. A careful study of the case has convinced me that this is due to the extreme shyness of the moth, which prevents it from stopping and depositing its eggs in such exposed situations. Scare it up in the daytime and it at once darts off to a place of concealment in the thickest growth it can find; and if you watch it

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flying of its own accord late of an evening or at night, you will invariably find it choosing its stopping places in obedience to the same rule; you rarely see it stop on any of these exposed plants of the border.

Trees.—I have often been asked to explain why cotton plants growing in the immediate neighborhood of trees are longer exempt from destruction by worms than those growing where trees are not. Some investigators have attributed it to the work of birds, which, finding a convenient lodging place upon the trees, have devoured the insects; while others attribute it to shade. I know it is not due to birds devouring the worms, for I see the same thing around trees that birds never frequent; and I know shade is not the cause, for I find plants exempt all the same on the north sides of the trees where shade cannot come. It is, evidently, this same peculiar shyness of the moth which causes it to avoid exposed situations. If you watch it in its voluntary flight, as I have done, you will see that it invariably gives all trees a wide berth. This is, in all probability, due to its instinctive fear of birds that *might* be lodging upon the trees.

Shade.—This does, however, afford a temporary annoyance; not to the moths, for they being nocturnal in their habits do all their work under shade, but to the worms. In my search for a solution of this tree-problem, I stretched a tarpaulin upon stakes above a number of plants so as to shade them. There was a goodly stock of worms upon the plants at the time, but in a day or two afterwards they had all changed their quarters to other plants and sunshine. But they returned to their work in full force when a trimming out of the field had brought nice, fresh cotton leaves into better demand.

NATURAL ENEMIES.

Entomologists who write on the subject of cotton insects usually find a great deal to say with reference to the "natural enemies" of the Cotton Worm. These they point out as existing among the quadrupeds and birds, and among other species of insects. To the quadruped portion of the subject I have given no attention, but birds as Cotton Worm destroyers and some of the insects I have studied extensively and with great care.

Birds.—Soon after I had located at Calvert reports were brought to me by several planters setting forth that immense numbers of small but strange birds had appeared on their plantations and were devouring the Cotton Worms. I found the "strange bird" to be a small black, white and buff sparrow of the species known to science as *Coturniculus lecontei*. As we approached the cotton fields it flew up in considerable numbers from among the plants along the edges bordered by woodlands, where it had been feeding upon the worms, as the contents of its stomach, examined in several specimens shot, plainly demonstrated. I was rather surprised to see it in numbers so large, owing to the fact that it has usually been regarded by naturalists as rather a scarce bird. Of course it was not a strange bird for Texas; it had now for the first time attracted the attention of these planters—that was all.

The Texas bird that I found standing first in rank as a devourer of Cotton Worms was the common Mocking Bird (*Mimus polyglottus*); and next to this, perhaps, was the American Cuckoo (*Coccygus americanus*). I saw neither of these birds catching moths; the only bird I saw actively at that business to an extent worth naming was the Bee Martin, or King Bird, of Texas (*Tyrannus verticalis*). It was quite plentiful on the Brazos, and I often saw it in the cotton fields after sunset catching moths, and not unfrequently continuing at its work until twilight had considerably advanced beyond the half-way line between daylight and darkness.

Ants.—I made many experiments with ants for the purpose of gathering some idea of the extent to which they are the "natural enemies" of the Cotton Worm. Put chrysalides of Aletia at the openings of ant-hills of all the species I was able to find in the cotton field, including those of the common and conspicuous *Pogonomyrmex barbatus*, or "Agricultural Ant of Texas." When first put down the ants usually tugged at the small extremities of the chrysalides for a few moments, after which they left them undisturbed. In not one of the species was there ever evinced the slightest disposition to break the shells. On one occasion I partially crushed several chrysalides until the juices appeared; these the ants of each species to which they were offered worked upon vigorously until they were either devoured upon the spot or dragged piecemeal into the habitation.

One morning I placed a number of chrysalides of Aletia, still rolled up in the leaves, at the opening of a strong colony of *P. barbatus*. Returning in the evening to see what had happened I found the ants busily engaged cutting the then dried leaves in pieces for the sole purpose, evidently, of removing them from their clearing. It is a peculiarity of this ant to keep every thing cleared away from the entrance to its den for a space of 10 or 15 feet in diameter, not even sparing cotton plants or those of any other crop that the farmer may happen to put within the boundaries of its claim.

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Already several leaves had been wholly cleared away, but the chrysalides which they had contained were still lying upon the ground undisturbed, they being too heavy to remove entire, and the ants, for some reason best known to themselves, having declined to cut them in pieces.

On various occasions I offered eggs of Aletia to many different species of ants, but not in a single case could I induce them to cut one from the leaf, though if I broke the eggs loose for them they would seize upon and carry them off without hesitation. Some writers claim that ants ascend the cotton plants and devour the eggs of both Aletia and Heliothis. This, I am fully convinced, is an entire mistake, especially so far as relates to Texas ants. My eyes are very good, and I have kept them open looking after this thing throughout the season; were it common, as has often been claimed, I surely would have seen something of the kind, which I did not.

As to the Aletia larvæ, or Cotton Worms, my observations have convinced me that some species of ants will destroy them, especially young worms, if placed near the entrance to their hills. But the cases of this destruction that will fall under the eyes of an observer are far less common than one might suppose. In most instances the worm, so soon as touched by an ant, goes into a series of skips and bounds which carry it several inches, and perhaps feet, away. The sudden movement seems to frighten the ant, which rarely starts in pursuit. If a new contact happens to result from another passer, away goes the worm again as before, until it is finally out of danger and up a cotton stalk. Have never yet seen an ant attack a worm of any considerable size on a plant, though it is no uncommon thing to see ants walk directly over worms. The large ants seldom ascend the plants for any purpose; the small ones that go up seem to have been attracted either by the exudations from plant lice or by plant nectar.

I have seen nothing to convince me that ants are of much value to the planter in their rôle as "natural enemies" of the Cotton Worm. I do not question the assertion that they devour large numbers of worms, but if the whole truth was known it would be found, in my honest opinion, that nearly all such worms were either maimed in some way or fatally sick before the ants took them in hand. I am sure that in Texas, at least, the good they all do is more than overbalanced by the evil wrought in the work of the "Agricultural Ants" in making their "clearings" in the cotton fields.

Other insects.—My investigations with reference to other insect enemies of the Cotton Worm were not so thorough as in the case of the ants, my instructions not demanding it; but in the course of the season I saw on duty most of the insects referred to in Bulletin No. 3 of the United States Entomological Commission, and nothing additional, showing that the work of the Commission had already been quite thorough in this direction, for Texas at least.

The only thing that struck me as particularly new under this head, growing out of my investigations, was the idea that entirely too much importance is usually attached to the "natural enemies" of the Cotton Worm. So far as mere natural history is concerned this part of the subject is worthy of due consideration, of course, but I cannot regard it as being of any particular interest to the man who concerns himself only as a practical cotton planter. What cares he as to how many friendly birds or insects feed upon his insect enemies, provided there are not enough of them to save his crop? I am sure that enough have never yet appeared to save the cotton crop in a season favorable for the growth and multiplication of Cotton Worms; and I am also sure that enough to secure such an end never will appear. This being the case, what does the planter gain from them? They leave him standing exactly where he would be found standing were they not in existence. It would cost him no more to poison the plants for the comparatively small addition of Cotton Worms that would claim his attention in case these "natural enemies" had not taken their share than it costs him as it is. The poisoning to be effectual must be thorough; nothing short of this will ever answer.

But, possibly, some will argue that these "natural enemies" may appear in force so large as to hold the Cotton Worms under check in such seasons as are not otherwise favorable to their development. If arguments of this character are presented they will be mere speculations unsupported by facts. Where are those "natural enemies" in the seasons when worms do not injure the crop? One never sees them on such occasions—one never will.

I contend, without fear of being wrong, that the appearance of these "natural enemies" in the field is merely a result growing out of favorable conditions for their attraction, or for their own multiplication, and that most prominent among these favorable conditions is an abundant crop of Cotton Worms to supply them with food. It is all nice enough to regard them in the light of friends, which they are, in a certain sense; perhaps it would be better to reckon them as our guests who have dropped in from the "hedges and highways" in compliance with our wishes, *after the feast has been spread*, but who would never have thought of responding to our bidding had we invited them to a festal board made up of empty tables.

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THE YEAST FERMENT REMEDY.

Obedient to orders in "Supplementary Instructions" I put this proposed remedy for the Cotton Worm to many careful tests, employing three grades of yeast, or "ferment," in my experiments. No. 1 was a duly prepared yeast obtained from a brewery; No. 2, the same, obtained from a bakery; and No. 3, a preparation made by myself after Professor Willet's plan as laid down on page 71 of Bulletin No. 3. The yeast was diluted with water to various strengths, and sprinkled upon the plants and worms, both in the open field and under gauze-covered boxes. The boxes used were large dry goods boxes from which both top and bottom had been removed. They were placed over living plants in the field that had been liberally stocked with worms, and sprinkled with the preparations, after which a thin cotton gauze, as mosquito barring, was tacked over the top of each.

The closest possible attention was given to these experiments through an ample lapse of time for their perfect development. Nothing resulted to indicate that the remedy was of any value whatever.

PYRETHRUM POWDER.

The powder used by me in my experiments was the California preparation sometimes seen upon the market as "Buhach." I began operations by inverting two glass tumblers upon several thicknesses of soft paper, and placing under No. 1 five grains of pyrethrum powder, dry, and under No. 2 the same quantity mixed with water to a thin paste. Next I placed under each tumbler two lively Aletia moths taken from my breeding-box. The moths flew up and took positions immediately under the bottoms of the inverted tumblers.

One minute, all the moths were seen to be shaking or twitching their wings. Five minutes: all had fallen to the paper. When I struck upon the tumblers with my hand they fluttered up, but immediately fell back again, having apparently lost the power of holding to the glass with their feet. Fifteen minutes: both moths in No. 1 were unable to fly up when I struck upon the tumbler, but lay upon their backs and moved their feet sluggishly, as if in the act of walking. No. 2 flew up the sides of the tumbler and fell back as usual. Thirty minutes: No. 2 could rise no more; each of the four was lying upon its back, slowly moving its feet. In six hours all were dead, No. 1 dying about half an hour sooner than No. 2.

This seems to prove that the dry powder is more prompt in its action than when moistened with water.

At early twilight I closed my windows and turned loose in my room six lively Aletia moths, after having dusted upon the head and thorax of each a very small quantity of dry pyrethrum powder. They flew up and settled about the ceiling and windows.

Five minutes: each showed that peculiar twitching of the wings that had been seen early in the course of the preceding experiment. Fifteen minutes: three were down on the floor unable to rise. Twenty-five minutes: all were down and helpless. I collected them in an open wash-bowl; next morning all were dead.

Sprinkled two rows of cotton running across a square acre, with pyrethrum powder in water at the rate of one-fourth of an ounce to the gallon; also, two rows with the same at the rate of half an ounce to the gallon. The plants were heavily stocked with worms in almost every stage of growth, it being late in the season when the broods were not marked with much regularity as to time. The weaker solution thinned out the worms somewhat, but did not give full satisfaction; the stronger solution entirely cleared the plants—next day not a living worm was to be found upon the rows sprinkled with the stronger solution, though there were plenty of dead ones to be seen, usually upon the ground.

I made a dusting implement by fitting the pipe of a small hand-bellows into a small tin box, and perforating the top of the box with many minute holes. A dry powder placed in the box could be forced through the perforations by working the bellows with care, thus enabling one to spread it quite thinly and evenly over the leaves of plants. With this I dusted two worm-infested rows of cotton with dry pyrethrum powder unmixed with anything, at the rate of about one pound to the acre, throwing it as much as possible against the undersides of the leaves. This brought no satisfactory results, which was, I take it, on account of the extreme lightness of the powder preventing it from flying with force sufficient to stick to the leaves, and also enabling a very large proportion of it to float off upon the air. I subsequently applied it in the same way mixed with dry London purple at the rate of one pound of the purple to four ounces of pyrethrum. This gave it weight and consequently a better sticking capacity. The result was very good—in from two to three days not a worm was to be seen on the plants.

I conducted many experiments with pyrethrum looking to a fixing of its volatile principle, so that it might be applied in the open field and made more lasting in its effects.

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While not positive, I am strongly inclined to the opinion that I have hit upon something that will prove all that is required in that direction. It consists in simply mixing the powder with a solution of starch prepared and cooked as for use in the laundry, though made considerably thinner. A common paste, or a mere mixture of raw flour and water will not answer; it must be "starch," a cooked solution, which is almost entirely transparent.

Several times, just before leaving Texas, I put this preparation to test with fine results, though time did not admit of my making the experiment as thorough as I could have wished. The experiments that I did make consisted in sprinkling cotton plants with the starch and pyrethrum mixture, and then stocking them with worms two or three days afterwards. In each case the worms fed upon the starched leaves and died.

I expect this to cross the views of many who hold that pyrethrum does not kill by going into the stomach; I shall not contend that it does. All I *know* about the matter is that the worms fed upon my pyrethrum and starch-sprinkled plants and died very soon afterwards. It is evident that the starch drying over the particles of pyrethrum had sealed them up, and protected them from the atmosphere. Each particle was inclosed in a minute capsule, as it were, and it does not appear impossible that the worm, in its feeding, may have cut open one of these capsules and unwittingly liberated the death-dealing principle confined within, thus exposing itself to the effect without having eaten any of the contents.

On reaching home I found some very large caterpillars (*Sphinx catalpæ*) feeding upon my seedling Catalpa trees in the nursery bed, and wishing to see what pyrethrum would do for these worms I deposited a mere speck of the powder upon the heads or bodies of some of them. In about five minutes they had discovered that something was wrong, and were beginning to flirt themselves about after the manner of such worms when a parasitic fly is troubling them. A green juice was forced from their mouths and thrown over their bodies, but all in vain—in a few hours they were dead. And the singular manner in which they disposed of their own "mortal" remains interested me exceedingly—they never fell to the ground, but invariably hung their heads over the petiole of a leaf, let go with all their feet, and died, leaving their bodies thus strangely suspended, where they were to be seen for days afterwards.

Wishing to further test my starch and pyrethrum mixture, I selected a young catalpa, growing some distance away from the main bed, and sprinkled the under sides of its leaves with the mixture, intending to stock it a few days later with worms. That night heavy rains fell; in fact it rained heavily and almost incessantly for several days, at the end of which time the worms were about all gone for the season. Of course it was but reasonable to suppose that the mixture was all washed from the young catalpa under experiment, and that, therefore, my test was ruined; it was now too late to begin it anew. Finding three worms on some of the other plants I placed them upon the catalpa under mention and went about my business, giving the matter no particular thought further. This was in the morning; in the evening I chanced to pass the same way, and, judge of my surprise, there hung the three worms from the leaf-stalks of the young tree, dead. On examination I found where each had eaten a small portion of a leaf.

OTHER VEGETABLE POISONS.

I went to Texas entertaining great hopes that I should find among the native plants of that State some substitute for pyrethrum, or, at least, something that would approach towards it in value as an insecticide. Under this stimulus I put to practical test a large number of plants, some of them botanically related to pyrethrum and many otherwise. My course of procedure was to dry and pulverize the flowers and leaves, and apply the powder so obtained on the plan usually resorted to with pyrethrum. I regret being forced to report that my efforts in this direction were wholly unrewarded; I found nothing that deserved to rank higher than a mere temporary annoyance to Cotton Worms, driving them, to some extent, but not killing them.

ARSENICAL POISONS—LONDON PURPLE.

It has been published that London purple suspended in water at the rate of half a pound of the former to forty gallons of the latter, and sprinkled over the plants, would prove entirely effectual as a poison for destroying the Cotton Worm. In the hands of a professional scientist so small a proportion of poison might be made to act very well, but experience and observation in Texas has convinced me that it is too small for general use among planters, especially with the rude kind of machinery now commonly employed for putting it upon the plants. Three-fourths of a pound to forty gallons is a proportion small enough for the poison. This will destroy the worms, and if well and evenly put on will never injure the plants—in fact, one pound to forty gallons will work no injury to the plants worth naming if kept well stirred up in the water, and thrown finely and evenly over the cotton.

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I made some careful experiments with dry London purple, undiluted with anything, for the purpose of deciding whether or not it could be applied successfully and made effectual in this condition. The implement employed in the applications was the bellows-and-box arrangement already mentioned in connection with pyrethrum. With this I dusted double rows of cotton plants across a square acre, the worms upon them being in strong force:

No. 1, under side of leaves at the rate of two pounds of purple to the acre; No. 2, same, at the rate of three pounds to the acre, and No. 3, thrown over the plants generally at the rate of two pounds to the acre. All the young worms still on the under sides of the leaves of Nos. 1 and 2 were promptly cleared off, but some large ones remained for several days on the upper sides of the leaves, though they did not seem to be feeding. The leaves were more or less scorched by the poison, especially on the rows dusted at the rate of three pounds to the acre. But the rows dusted promiscuously at the rate of two pounds to the acre showed the best results—the worms were all cleared off, while very little damage was done to the foliage.

Of course a good deal of the scorching may be charged to the rudeness of the implement with which the applications were made, it not distributing the powder with entire regularity. But even so imperfect a test settles it, in my mind, that there is really no need of diluting London purple with anything save air—a machine can be invented that would apply it in this condition as successfully as in any other. My idea of such a machine pictures something on the plan of the revolving "fan" or "blower" used by blacksmiths or foundrymen, with an attachment qualified to feed the dry purple in from a hopper only just so fast as needed. I think such a machine can be gotten up easily and with very little complication in either its construction or manner of working.

With a view to testing whether or not the *moths* of Aletia are killed by the application of London purple to the plants, I affixed two large dry-goods boxes each over a small living cotton-plant, as in the yeast experiment. The plant in No. 1 was carefully sprayed on the under sides of the leaves with London purple in water at the rate of three-fourths of a pound to forty gallons. Nothing was put upon the plant in No. 2. Under each gauze-covered box, with the plants, were placed twelve lively Aletia moths, taken from my breeding box, where they had been two days without food. Next day found six moths dead in No. 1 and two dead in No. 2. And the *next* day found three dead in No. 1, and none dead in No. 2. Replaced the dead moths with living specimens, after having sprayed both plants promiscuously with the same mixture as used at the beginning of the experiment. Next morning found four moths dead in No. 1 and seven in No. 2.

At the time of the season when the Boll Worm was most actively at work, I made an experiment looking to a decision as to whether or not sprinkling the plants with London purple had any bad effect upon that insect after it had ceased to feed upon the leaves. Selecting several heavily-fruited plants, I spread dry London purple carefully over the bolls, applying it thinly with a camel's-hair pencil. It protected every boll. While a large per centum of the bolls on all the neighboring plants were afterwards bored into, not one to which I had applied the London purple was damaged in the least.

I applied London purple to many eggs of Aletia, spreading it thinly over them, dry, with a camel's-hair pencil. I think it destroyed every egg so treated.

PARIS GREEN.

My experiments with this article were limited to a few applications made with the poison suspended in water for the purpose of determining how small a quantity could be made effectual as a destroyer of the Cotton Worm. The poison was obtained of a dealer in Galveston, and was supposed to be as pure as any on the general market. It gave entire satisfaction, mixed in the proportion of one pound of Paris green to forty gallons of water, and thrown over the plants promiscuously with a force pump in finely divided jets; but less than one pound did not prove a decided success. This quantity entirely cleared off the worms, and did not seem to injure the plants in the least. I added neither starch nor flour, but to one application I added common salt in the proportion of two pounds to the forty gallons of water. The salt gave a greater specific gravity to the water, thus, as I thought, aiding in the suspension of the Paris green.

ARSENIC.

The poison employed in these experiments was the common white arsenic (*Acidum arseniosum*), costing, landed in Texas, from 3 to 4 cents per pound by the barrel.

The first three tests were made with the poison in a dry state, applied undiluted to the plants by means of the bellows dusting-implement already described. Each experiment covered two rows of cotton running across a square acre, and well stocked with worms in various stages of growth.

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No. 1, thrown against the under sides of the leaves at the rate of 2 pounds of dry arsenic to the acre; No. 2, same quantity thrown promiscuously over the plants, the upper sides of the leaves getting the larger share, of course, and No. 3, applied in the same manner as No. 2, at the rate of 1 pound to the acre. Nos. 1 and 2 destroyed all the worms, but burned the leaves of the plants badly. No. 3 showed only a partial clearing out of the worms, while the leaves of the plants were more or less scorched.

A permanent solution was made by adding to 5 gallons of water 5 pounds of arsenic and 1 pound of sal soda, and boiling over a fire in a common iron pot until all the arsenic was dissolved. This makes a solution of arsenic that will keep for any length of time without the slightest precipitation.

Of this solution 1 quart was put into 40 gallons of water, which was then sprinkled over the cotton-plants in the usual way. It destroyed the worms, which were in strong force when the application was made, leaving the plants uninjured to any extent worth naming. Several similar tests were made, all with uniform success. Forty gallons were found amply sufficient to go over an acre of cotton of ordinary growth.

Here we have a remedy with which we can save our crop from the Cotton Worm at a cost of 1¼ cent per acre, rating the price of arsenic at 4 cents per pound and that of sal soda at 5 cents, which would be very high for the latter. This, it seems to me, is whittling the matter of cost down to a point decidedly fine. Of course, there must be added to the cost of the drugs the further cost of preparation and application. The cost of application can be no greater than that of applying any other liquid remedy; indeed, it should not be so great as in the case of some of them, owing to the fact that the liquid is a perfect solution, and, therefore, will not require the agitation necessary to keep insoluble poisons in suspension. The cost of preparing the saturated solution might be put down as a very small item against arsenic, but I think this is more than offset by the advantages of having a perfect solution at the application; then, since the saturated solution will keep an indefinite length of time, it may be prepared at odd spells, when there is nothing else in particular to do.

I am aware that a strong prejudice exists against the use of arsenic as an insecticide, the prejudice growing out of the mere fact, doubtless, that arsenic is well known by name as a deadly poison. Many persons who use London purple or Paris green upon their cotton without hesitation could not be induced to use "arsenic" under any consideration. They would tell us that to tamper with so virulent a poison as arsenic is extremely dangerous, while there is no particular danger attending the use of either of the other two articles named. Nothing could be more foolish! I grant that it would not do to use a solution of arsenic for drinking purposes, nor for shortening one's biscuit, neither would it do any better to so use the water holding in suspension an insect-destroying quantity of either London purple or Paris green. The three poisons are really one and the same thing after all, the agent in both London purple and Paris green, qualifying them to destroy Cotton Worms, being arsenic and nothing else. Remove the arsenic from them and they would be no more effectual as insecticides than powdered chalk or common road dust. They are all deadly poisons alike, taken into the stomach—keep them out of that organ, and there is no danger in any of them.

The planter who uses arsenic as an insecticide, preparing it in advance as suggested, should have a good whisky or oil barrel for containing his solution until wanted. This might be painted some bright color to strongly distinguish it from all other barrels on the place, and it would be well to have the word "arsenic" or "poison" painted (not daubed) in large plain letters upon its side. With such precaution as this, and keeping the barrel well bunged and out of the way of small children and live stock, there could certainly be no attendant danger.

The rule which I have given for preparing the second solution might not hold good in every instance on account of variation in the quality of arsenic, due, possibly, to adulteration. A good and safe way to set this thing right—one that every planter will understand—is to make small tests in advance of the general application as follows:

With some small vessel, as a tablespoon, put together 160 measures of water and one measure of the saturated solution. This gives you the proportion of one quart of saturated solution to forty gallons of water. Sprinkle this thoroughly over an average hill of cotton, and wait a day or so for results. If no sign is left upon the plants the solution is not strong enough, and you must repeat the experiment with a little larger proportion of the saturated solution. If, on the other hand, the plants show the leaves considerably scorched and damaged, the solution is too strong, and you must repeat with a reduced proportion of the saturated solution, measuring with great care, however, so that you will be able to come exactly at the extent of addition or reduction when you make your diluted solution on a larger scale. If, after your application, you find the leaves showing only an extremely slight mark of scorch—an occasional leaf curled a little at the edge, perhaps, and a small brownish

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or "piebald" spot here and there on some of their interiors—your solution is just right. These very slight scorches are what you want to see—while they will not damage your crop in the least, they will assure you that you are giving the worms a dose sufficiently strong to make a rapid and thorough finish of their work as cotton destroyers. With your solution at this strength you need have no fears of injuring your plants, put it on as you may; for, unlike a liquid merely holding a poison in suspension, every drop applied is the same in its effect.

Respectfully submitted, January 1, 1881.

J. P. STELLE.

Prof. C. V. RILEY,
Chief U. S. Entomological Commission.

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APPENDIX IV.

REPORTS OF DR. E. H. ANDERSON.

REPORT FOR 1880.

CANTON, MISS., *October* 20, 1880.

SIR: As your appointee, I have the honor to make the following report.

After diligent search, commencing as early as the middle of June, I saw no sign of Aletia until the first week in August, and then in my locality, Kirkwood, Miss., found but one larva, that full grown and on the top of the plant. On the other hand, from the 1st of July, the visitation of the Boll Worm was made manifest, and from then until the present time it has continued its destructive operations, doing about the usual amount of damage, and probably shortening the crop 10 per cent. During my investigation in July I found several worms upon the cotton leaf, one among which, while I had it in my hand on the leaf upon which I found it, commenced to web up, and while engaged in this would apparently stop to gather fiber from the under surface of the leaf with its mandibles, throwing its body from side to side as it spun its web, and would occasionally stop and eat a circular hole through the leaf, such as we frequently find early in the season, and might suppose to be the work of the Cotton Worm, but the circular form should distinguish it from the Cotton Worm, as Aletia always eats along a line. I found other small worms also webbed up in terminal shoots, but the injury to cotton so slight as to be inappreciable. Finding that Aletia had not visited my locality by the 20th of August, and judging from the low temperature of the season that we would have them, the worms, in too small numbers for experimental purposes, I went to Canton, where I had heard of them, and where they are almost annual visitors, though this season coming too late to do much damage. They were first discovered, as I learned through correspondence with the proprietor where they were found, on June 22, and he informs me that they have been annual visitors for years past. His place is elevated and undulating, having a red clay substratum, and consequently retains moisture well, and his system of culture is flat, in order to prevent washing. It is bounded on the north and northwest by woodland and has an orchard and grove on the south, elsewhere open and bare. The worms first made their appearance on one of the most elevated spots in the field, the first brood eating to a limited extent. At a later period they were discovered at another point on a slight declination, and extended their area, and still later on the top of the ridge, widening their area, and finally were to be found all over the cotton, but too late to do actual damage. Let it be borne in mind that this field, or rather this plantation, had been diligently worked and annually fertilized to some extent both with cotton seed and compost, and although the corn land received the fresh manure, the system of rotation of crops gave the cotton the benefit of the previous year's manuring, and by leaching all received a proportion of the benefit. Those who advocate the theory that the succulent and luxuriant condition of the plant such as is oftenest found in low and wet spots, and where an exuberance of nectar might be found, is more inviting to the moths, would find it difficult to explain why they were found on these elevated spots referred to and similar spots referred to by Mr. Trelease in his report of 1879. Those who favor the ant theory could not so well see or explain why the ants did not prevent the increase of the worm on these elevated ridges where there was nothing to prevent their building hills and pursuing their predatory habits.

I admit that the worms are oftener found in wet spots than elsewhere, and I think for an obvious reason, but I cannot assent to the proposition that they first appear *naturally* in such spots. Early in the season, I think they would be found where the sun had freest access to the cotton, and where fertilizers had stimulated its growth, and this would more likely be upon elevations. Upon such cotton have I found the first worms the past two seasons. Though the question of hibernation is still unsettled, Professor Riley's investigations have rendered it almost certain that it appears much earlier in the season here than had been previously supposed, and as full-grown

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worms and chrysalides have been found in this latitude—33° N.—as early as the 22d of June, the presumption is that diligent search would reveal them still earlier, and the conclusion is irresistible that they pass through our winter in some form, and are developed by the first hot weather, and from thence continue their transformations, accelerated or retarded by meteorological influences, to the end of the season. As I know from practical experiment that the temperature of the air near the earth is increased by stirring damp or wet soil (see p. 147, Patent Office Report, 1870), and also by the decomposition of fertilizable matter; and as the hatching of the egg is dependent upon a certain degree of heat and moisture, I can readily apprehend how in early hot weather the few eggs that may be placed upon the plant may be speedily hatched. In the cases cited, where the worms appeared upon elevations in June, I think it was due to the combined causes of artificial heat from decomposition of fertilizable matter and stirring damp soil. The difficulty in bridging the gap from March to the first appearance of the worm in cotton, referred to by Professor Riley in Bulletin No. 3, p. 28, may be solved on the theory that the worm is hatched out under favorable circumstances during warm spells in April and May, but in such small numbers as not to be noticeable. If we assume the fact that they are not hatched out until cotton has attained a certain growth, and that they will eat nothing but cotton, the question may be asked, On what does the larva of the cotton moth feed that has been found on peaches, watermelons, and other fruits in the North, where reliable entomologists say they are found? Later on in the season, the speedy evaporation of dew and rain in showery weather into vapor constitutes the true causes of ordinary solar hatching, and I believe the egg of Aletia to be as dependent upon atmospheric conditions and long terms of heat and dampness, such as recur only at irregular intervals in this latitude, for its spread over large areas as I believe the germ of yellow fever to be dependent for its production and dissemination upon similar causes. There are in special localities so many modifying agents as to make it impossible to apply general principles to all alike. Ignoring this fact has led to discrepancies among observers and a diversity of theories to account for certain observed phenomena. Take, for instance, the more frequent appearance of the worms in wet spots, and their development there in larger numbers. One, as Mr. Davis, of Texas, for instance, accounts for it by supposing that the presence of the worm is due to the absence of the ants, their arch destroyers. Others attribute it to the luxuriant and succulent condition of the plant as furnishing preferable food for both moth and larvæ. Each one of these views is sustained by apparent facts, and yet all combined are not sufficient to account satisfactorily for a phenomenal circumstance which we often witness, and which has been strongly emphasized by Dr. Phares as a remarkable topographical feature. It is the unexpected appearance of the worm in wet spots or limited areas in such numbers as to destroy the cotton, stripping it of all its leaves and young bolls, eating up to a line and then disappearing, where, as he says, ants were on both sides of the line in like numbers and the plant in like condition. This striking feature has been noticed by myself on many occasions, yet only after the land had been disturbed by the plow while in a wet condition; and having tested by the thermometer the condition of the lower stratum of air after plowing, and having found the temperature increased thereby from 10° to 12° F., and by parity of reasoning knowing that it would be increased proportionately in damp soil; and observation through a series of years having convinced me that heat and dampness were the main factors in the hatching process (see p. 18, 19, 20, in Bulletin No. 3), I have arrived at the conclusion that artificial heat and dampness, thus produced, hatch out a larger number of eggs than all other causes combined, and the reason why it is not of annual occurrence in this latitude is that a high degree of temperature, alternating with showers and sunshine, must prevail, and this is only of periodical occurrence. Farther South this condition would characterize the seasons to a greater or less extent, particularly along the Gulf coast and inland up to a certain degree, or so far as, owing to geographical position, the territory was under the influence of the warm tropical winds loaded with the moisture of the Gulf. In this more southerly belt, I have no doubt, natural causes operate to produce an annual crop of insects, as the temperature would enable them to pass through their transformations continuously.

The advocates of the ant theory all likewise advise not to plow wet spots or wet land, for the reason, as they say, that by so doing the ants are disturbed and destroyed; but, according to my observation, there will be at any time but few ants frequenting such spots, and especially early in the season or before midsummer and by midsummer. If the worms have been developed early they will spread over the elevated lands in despite of the ants, though there they most abound. Entomologists have established the fact that the ant is in quest of sweets, though almost omnivorous in its appetite; and as the cotton plant is infested with insects that secrete sweets, as well as nectar producing, and as the ants are always found there, whether there be any worms or not, the conclusion is irresistible that a worm diet is exceptional, and in the aggregate amounts to but little in the way of protection to the crop. I have watched the ants sipping nectar from the bracts of the May-pop flower as well as

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others, but never saw them attack an insect. I have made it a special object to notice the habits of the different insects visiting the cotton flower, to satisfy myself as to its reputed nectar glands, and often observed bees especially visiting those at the base of the involucre. They invariably visited each gland, passing from flower to flower, and repeating the operation. The larger bees confined themselves to the outer glands, while the smaller invariably went within the flower and came out loaded with pollen. I saw the Boll Worm moth also visit the outer glands, but, though having often watched, have not seen the midrib gland visited, though have frequently found it filled with a sweet. The nectar glands have been so fully and ably treated by Mr. Trelease, and the visits of the moth to them verified by Professor Riley, as to establish the fact and reveal a new feature in the natural history of this interesting insect.

In my investigation this season, I had the opportunity of seeing the jute growing in the midst of cotton. It had been planted in May, and when I saw it, late in August, had attained the height of 8 to 10 feet, and was luxuriant. The row, about 200 feet long, was surrounded by cotton, the row of jute running parallel with the rows of cotton, and the worms were abundant on the cotton in the midst of the jute and touching their leaves. Its effect was nihil.

Among the insects found eating cotton late in August was *Saturnia io*, the Corn Emperor Moth. It appeared in a small field of cotton near Canton, and would doubtless have stripped the cotton had it not been hand-picked and destroyed. It probably reached the cotton by migration, as a garden adjoined the field. Their conspicuous size made it an easy matter to find them, and hence their destruction could be easily effected by brushing them off and crushing.

I have met with but one larva that I did not recognize as having been described by other observers, and that one I found preying upon Aletia larvæ in the act of pupation, and found it so frequently as to induce me to think it quite destructive to this insect. This I sent to the Department for identification.

The London purple was tried under my supervision in two ways, wet and dry. The dry powder was mixed with cotton-seed meal and flour in the proportion of one to thirty, and dusted over a small area, and in a short time the worms ceased to eat, sickened and died. The dry process, without proper sifters or dusters, would be impracticable over large areas, and without proper distribution would prove injurious to the plant and could only be used to advantage while the dew is on or just before a rain. Its effects, however, seem to be quite permanent as the worms continued to die for some time after the application, though showers continued to fall. The dry application would require greater precaution on the part of the operator, and may be considered less safe than the wet. The wet in the proportion of 1 pound to 40 gallons of water proved equally effective, and with a good fountain pump may be used without any risk. After the wet application the worms continued to die for several weeks, though several hard rains had fallen in the mean time, and while the leaves showed to a small extent the effect of the poison, the plant generally retained its freshness, while adjoining unsprinkled cotton was stripped bare. I think the result of these experiments will inspire confidence in the use of poisons in this locality and do away with much of the prejudice heretofore existing in regard to them, especially as the gentlemen, Smith-Vaniz Brothers, upon whose plantation they were made, are prominent members of the County Agricultural Club and intelligent and skilful farmers. As to London purple as an insecticide, in the proportions above mentioned, there is no doubt of its entire efficacy, and as it is both cheap and permanent in its operation it must eventually come into general use. As my opportunities for experiments with poisons this season have been limited, I should have occasion for regret did I not know that abler and far more expert hands have been engaged in this work elsewhere.

By direction of Professor Riley I have given more attention to experiments with pyrethrum extract and yeast. The only preparation I could obtain was the extract furnished me by Professor R. W. Jones, of Oxford, and prepared by himself, and at his suggestion I used it in the proportion of one to thirty of water. This I applied by sprinkling over the worms on the plants. In several minutes after the application the younger worms ceased to eat and fell to the ground; the older ones ceased likewise to eat, and in three or four minutes commenced writhing, and in twenty minutes all were on the ground, and soon in a torpid condititon and apparently paralyzed. As this was done in the afternoon, I cannot say whether they revived or not, though I found none on the ground, and but few on the plants. My belief is that they died. My next experiment was upon a number of large caterpillars found upon a rue plant. These, though greatly larger than the Cotton Worm, seemed more sensitive to the effects of the pyrethrum, as they showed great irritation at once, and in a few moments commenced writhing, and in five minutes all were in a torpid state on the ground. There were twenty on the plant. On my return in two days I found four on the plant and one dead on the ground.

My next experiment was upon young and old Cotton Worms, and, as in the first case, the young succumbed in a few moments, and the older ones in fifteen minutes, when

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they ceased writhing and became torpid and apparently dead; subsequent examination proved all to be dead. From repeated experiments I would give it as my opinion that the pyrethrum when directly applied to the larvæ would prove fatal to them, but the application would have to be repeated as often as the worms appeared, as its effects would be evanescent, whereas that of London purple is permanent, and would prove fatal to one generation at least. As the watery infusion or solution has been introduced and successfully tested by Professor Riley, and the plant may be cultivated by planters, and as a good fountain pump would enable the planter to spray his crop at small cost, this must become the popular remedy, especially as no risk is incurred by the operator in its use.

Yeast is entirely negative in its effects.

In my observations I frequently saw clusters of Soldier Bug eggs on the cotton leaf glistening in the sunlight, and made more attractive by the rim of spines crowning their apex. I also met often with the Aphis Lion eggs, with their long pedestals capped by their fleecy cones, and also the eggs of the Lady Bird.

The season just passed having been characterized by low temperature, and each spell of wet weather by a lower thermometer, infusorial and insect life has been at a minimum; and, in fact, mosquitoes had not proved annoying until late in September, during a hot, damp spell of weather. This late meteorological change likewise caused the worm to spread over larger areas, and gave me the opportunity of collecting large numbers of chrysalids of the fifth and sixth generations of Aletia, which I shall dispose of in glass jars and boxes, in and above the earth, so as to test fairly its hibernation, and in due time will report results.

I have the honor to be, with high respect, yours,

E. H. ANDERSON, M. D.

Prof. C. V. RILEY.

REPORT FOR 1881.

KIRKWOOD, MISS., *January* 2, 1882.

SIR: I have the honor herein to submit my report to you as head of the Entomological Department, acting under your instructions and in accordance with commission as received from Department. Owing to the advanced stage of the season when my work commenced, there was little else left for me to do except watch the insect at the period of its departure from the cotton fields, and concentrate my attention upon its mode of hibernation, and to ascertain, if possible, whether and how it passes through the winter in this latitude.

As so many observers, both experts and laymen, have made reports upon their unsuccessful efforts to find the moth of Aletia during the winter months, I adopted the plan of collecting chrysalids and eggs and subjecting them to different temperatures and watching their development, the results of which plan will be detailed in this report to its date, as has been from time to time substantially reported to you.

October 3.—Visited cotton field where I saw larvæ of all sizes and eggs in abundance on top leaves principally, one to the leaf generally, occasionally two. The insect now in its fourth brood. Ants observed to be busy about colonies of Aphides and sucking nectar from gland of midrib of leaf. A large portion of cotton bare of leaves, other portions full leaved, upon which worms of all sizes are now feeding and a second top growth, the result of recent showers, which will sustain next brood. Brought in a lot of chrysalids and eggs to watch development.

October 10.—Visited a field where I found that a large proportion of the chrysalids of the fourth brood had issued as moths. Eggs abundant, and larvæ of all sizes. Watched ants; but saw no new developments. Interested in seeing larva climbing its web, suddenly falling to the ground, as if accidentally, again ascending to the plant on a new web which must have been spun in its fall. Brought in chrysalids and eggs. Have put up box No. 1, containing 25 chrysalids; No. 2, glass jar, containing 23; No. 3, glass jar, a number of eggs.

October 11.—Two moths appeared in No. 1 box; one in No. 2.

October 12.—Five moths in No. 1; 2 in No. 2.

On the 11th put up 13 chrysalids in box No. 4, wire gauze top and bottom, one end glass, balance wood.

October 14.—Eleven moths in No. 1; six moths in No. 2.

October 15.—One ichneumon fly, parasite, in box No. 1.

Visited a field where I found the fifth brood webbed up, principally in persimmon leaves; the field was bare of cotton leaves. In last two visits observed the larvæ to be much darker, almost black, on casual inspection. No ants or other insects observed, doubtless owing to absence of food. This was the field in which the worms appeared first in this locality in considerable numbers, and that was about the 15th of July.

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Put up a number of chrysalids in wire-gauze box No. 5, and also in glass jar No. 6.

October 18.—One moth out in No. 5 box.

October 19.—Rain. Temperature, 56° F.

October 20.—Two moths out in box No. 4 (not Aletia); 2 out in No. 5; 7 out in No. 2, and 1 parasite. Temperature 52° F., 8 a. m. Put up 10 chrysalids in glass box No. 7, top and sides glass, bottom wood. This intended as a vivarium for observing copulation and procreation. 6 p. m., temperature 60° F. All the above chrysalids were found in leaves of Convolvulus, cotton stalks bare.

October 21.—One moth out in box No. 7. Temperature, 50° F., 7 a. m. Put five eggs on glass on box No. 1. Put up 61 chrysalids in wooden box with wire gauze top No. 8, soil on bottom, chrysalids laid loosely on top of soil. Temperature, 60° F. Rain.

October 22.—Four moths out in No. 5 and 4 in No. 7. Temperature, 66° F., 8 p. m.

October 23.—Rain.

October 24.—Temperature, 68° F., 8 a. m.; 1 moth out in No. 4; 5 moths out in No. 5; 6 moths out in No. 7; 8 moths out in No. 2.

October 25.—Temperature, 48° F., 8 a. m.

October 26.—Light frost; 7 moths out in No. 7.

October 27.—One dead moth in box No. 4. Temperature, 60° F., a. m. Visited a field where the worms had stripped southern portion, leaving a strip in northern part in full foliage; this strip skirted east and west by forest. Found a few chrysalids, no larvæ, eggs, or moths. These chrysalids were of the fifth brood. Rainy day.

October 28.—Visited a field with a small area left unstripped. Found a few larvæ full grown, black color predominating, still feeding but languid in appearance. No fresh eggs found. Brought in a number of chrysalids, many of which have not completed their transformation. An inspection indicates clearly that the case is formed from the larval integuments, the body forming its own sarcophagus. Rain. Temperature, 64° F.

October 29.—Transferred 7 chrysalids from box No. 1 to No. 3. Placed 21 chrysalids, brought in on the 27th, in box No. 1. Fifteen moths out in No. 5; 13 out in No. 1. Temperature, 64° F., 8 a. m.

October 31.—Forty moths out in No. 5; 3 out in No. 6; 8 moths out in No. 7. Temperature 58° F. Cloudy. Revisited a field visited on the 10th and found but little of the second growth of cotton left. Found a few larvæ large and small of the fifth brood, and also a number of fresh eggs on top leaves, as many as eight to the leaf, and, in one instance, twin eggs twice on the same leaf near together. These I have placed in a glass bottle, cutting the leaf into small sections, with the egg as deposited. Aphis and ants quite abundant. Only found ants among colonies of Aphides. Noticed that the leaves from which the lice had sucked all the juice of the parenchyma, and which were about to fall, were covered with lice. What becomes of the lice when they reach the ground?

November 1.—Visited two fields where there is yet considerable foliage; searched for larvæ and eggs of *Heliothis armigera*, but found none, and no indications of their presence, though green and young bolls were abundant. Brought in a few eggs and chrysalids of Aletia. Temperature, 68° F. Clear.

November 2.—Sixty moths out in No. 5. These were put up on the 15th, and have developed more rapidly than others. Moths in No. 7 (vivarium) depositing eggs. Temperature 64° F., 8 a. m.; weather clear. As the weather becomes cooler, have noticed the tendency of the moths to crowd together.

November 3.—Visited a field of fresh land cotton where I found northeast corner not eaten by the worm, the rest of the field bare. The leaves nibbled here and there and fresh and full of chrysalids; no fresh eggs. Found a few full-grown larvæ feeding. Searched diligently for Heliothis and examined a number of young and grown bolls, but found no eggs or perforations in the bolls or any sign whatever. No lice or ants were observed on this cotton. Temperature 43° F., 7 a. m. Brought in a number of chrysalids and a lot of larvæ.

In regard to Heliothis I may remark that, probably owing to drought, they have done no damage to cotton, and my inability to find them is owing to the fact of its desertion of cotton for other vegetation more succulent. I am at this date gathering green tomatoes and find a large proportion perforated by Heliothis and many ruined, so that in several bushels I lose a fifth or sixth, say about 20 per cent. My opinion is that we have here but four broods of Heliothis annually, first in corn, second and third in cotton, and last in garden and other vegetation.

November 4.—Temperature 34° F., 7 a. m. On visiting my garden, examined a cotton stalk in full foliage at the end of a tomato bed and found Aletia eggs on many of the top leaves and found two on outside of involucre. On one leaf found as many as eight eggs, two side by side in close proximity. Found also a young boll which had been perforated by a Boll Worm, but found no larva or egg on the stalk. Found two *Heliothis armigera* on tomato, one-half buried in the fruit; these I sent you. The frost has been a nipping one.

Found moths in box No. 5 crowded together and many in a torpid condition that

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subsequently revived. Sent you a number of chrysalids and larvæ brought in on the 3d instant.

November 5.—Temperature 48° F., 7 a. m. Transferred 44 moths from box No. 5 to box No. 7. Eggs now being deposited all over box (glass) No. 7.

Made box No. 9 without bottom. Loosened the earth so as to bring it into the condition of an ordinary fresh land cotton bed; sunk the box 2 inches. This will give normal earth temperature; nailed a board over a part of the top to protect from rain in order to afford hibernating shelter for the moth; over the rest of the top tacked a piece of coarse cloth for protection and to secure moths, through which rain will percolate, and where I shall place sweets. All under rough cover constructed for the purpose. Placed in this box 90 chrysalids brought in on the 3d. This is done in imitation of nature.

Put under same shelter box No. 10. This is a shallow box filled to within 2 inches of the top with loose soil, top arranged as last. This has a wooden bottom, but wood being a bad conductor would modify temperature. Put into this 140 chrysalids, which will be treated as last box. These boxes afford an excellent test for hibernation of the moth. In cutting up tomatoes six Boll Worms (Heliothis) were met with, which were sent to you. Being found in the fruit, *flagrante delicto*, settles the question of its feeding upon other plants or fruit than cotton. Visited a cotton-field and found the green cotton uninjured, though on the day before the temperature was 32° F., but not of sufficient duration to produce ice and destroy vegetation. Brought in eggs, larvæ, and chrysalids. No signs of Heliothis.

November 6.—Temperature 56° F. Rain.

November 7.—Cloudy and misty; temperature 56° F., 9 a. m. One dead moth in No. 7. Temperature, at 1 p. m. in the sun, varied from 74° to 84° F.; clear and cloudy alternately.

November 8.—Sent you a box containing Heliothis chrysalids and larvæ (Aletia). Rain p. m.

November 9.—Put in flower-pot 3 larvæ (Heliothis) in tomato, and one in cotton boll. Introduced 60 Aletia chrysalids into box No. 4, gathered on 3d instant. Put in box No. 11, 60 chrysalids, gathered on same date, wooden box, glass top, to be kept in house. Put in gauze bag, wooden bottom, 76 chrysalids, gathered 27th ultimo. Temperature 56° F., 1 p. m.; rainy and raw.

November 10.—Cloudy and foggy; temperature 62° F.

November 11.—Cloudy and foggy; temperature 66° F. Rainy day. Visited a field in which I found fresh chrysalids and larvæ. Foliage abundant. East side of field protected.

November 12.—Introduced 18 fresh chrysalids into box No. 1. Temperature 56° F., 7 a. m.

November 14.—Temperature 40° F., 6 a. m.; clear; wind north. Eleven moths in No. 4; 12 dead moths in No. 5; 3 moths in No. 1; 13 in No. 11; 13 dead moths in No. 7. Visited a field of late cotton, where I found foliage fresh and partially nibbled by the worm. Found a few young bolls perforated, the first evidence of Heliothis in my search this fall in cotton; the field a small one, contiguous to a garden. Found a few Aletia chrysalids; no eggs or larvæ. Aphides clustered in colonies within the involucre chiefly, and dark in color.

November 15.—Temperature 42° F., 6 a. m. Clear. Wind north. Visited a field where the foliage begins to show the effects of frost. Found a few chrysalids freshly folded; no larvæ or eggs. Found also a few young bolls eaten into, but whether by Heliothis or other insect am unable to say. The forms were not flared as usual. No other signs of Heliothis. Aphis and many other insects, especially Lady Birds, found well secreted.

November 16.—Temperature 46° F., 8 a. m. Visited a fresh field. Found it partially eaten by the Cotton Worm; leaves green and fresh. No larvæ or eggs to be found. Fresh chrysalids abundant and moths issuing therefrom. This is probably the sixth brood, and is certainly the last to appear in cotton. Brought in a number of chrysalids.

November 17.—Temperature 58° F., 8 a. m. Wind south. Introduced 25 fresh chrysalids in box No. 5. Removed 6 dead moths from same. Transferred 16 moths from No. 5 to No. 7. Introduced 25 fresh chrysalids into box No. 4. Placed these two boxes under shelter, with boxes Nos. 9 and 10 on the ground. Placed bottles with eggs under same shelter, on the earth, inverted. Visited cotton-field and found 1 fresh egg.

November 18.—Temperature 76° F., 1 a. m. Removed 5 dead moths from box No. 7; 5 from No. 11; 20 moths in No. 11; 12 moths in No. 1; 4 dead moths in No. 1. Visited a field of late fresh land cotton. Found fresh eggs of Aletia, as many as 7 on a leaf. In my glass box No. 7 the eggs are deposited indiscriminately upon glass, cotton leaves, stalks, and forms.

November 19.—Temperatute 46° F., 12 m. Wind northwest. Rain.

November 20.—Temperature 30° F., 6 a. m.

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November 21.—Temperature 42° F., 6 a. m.; 4 moths in No. 1; 12 dead in No. 1; few dead in No. 11; 11 moths in No. 11; 7 dead in No. 7. Visited a field of fresh land cotton, where the foliage was partially frost-bitten but much still fresh. Found one egg, recently deposited, and some chrysalids. Few insects noticeable. Placed 7 chrysalids in No. 11. Sent you 3 boll worms (Heliothis), taken from tomato.

November 22.—Temperature 42° F., 9 a. m. Raw and rain. No development.

November 23.—Temperature 42° F., 9 a. m. Raw and rain. Moths torpid.

November 24.—Temperature 28° F., 8 a. m. Freezing and clear.

November 25.—Temperature 20° F., 7 a. m. Freezing and clear. Visited a field. Found the plant in too unsatisfactory a state to make any examination, the effect of the severe freeze of previous night.

November 26.—Temperature 30° F., 8 a. m. Wind north.

November 28.—Temperature 40° F., 8 a. m. Wind north. Removed 20 dead moths from box No. 7. Introduced 40 chrysalids into same, brought in on 21st instant. Moth in a torpid condition.

Put up 80 chrysalids in box No. 12, brought in on 21st instant. Removed 4 dead moths from No. 6; 2 moths out in No. 8; 20 dead moths removed from No. 5; 19 dead from No. 4. Sprinkled dry earth one-fourth of an inch thick over chrysalids in these two boxes and replaced them on the earth. No development in boxes Nos. 9 and 10.

On close examination at 1 p. m. found the moths supposed to be torpid all dead. Removed 36 from No. 4; 2 from No. 1; 12 from No. 11; 32 from gauze bag. Not a moth in any of my boxes living or dead. Temperature at 1 p. m. 64° F. Moths living and in motion on the 21st, and supposed to be living for some days subsequently, as they did not change their natural position, were all killed doubtless by the freeze of the 25th instant. This would indicate that the moth cannot survive a temperature below 15° or 20° F.

In regard to copulation, from my observation, it is carried on most actively at twilight. When observing my vivarium by lamp-light I have witnessed no demonstration in that line. As eggs, however, are abundantly laid on the glass, leaves, and stalks of cotton, and the wooden sides of my boxes, procreation must go on normally.

November 29.—Brought in some chrysalids, found on Convolvulus leaves, where the vine ran on a cedar tree in a cotton-field. They appear to be sound. Put up in glass bottle No. 13.

November 30.—Temperature 63° F., 8 p. m. Wind southwest. Rain. Visited a field where I found chrysalids, to all appearance unaffected by recent cold weather. Sent some of these to Professor Riley.

December 1.—Temperature 44° F., 7 a. m. Wind north. Clear. Boxes unchanged.

December 2.—Temperature 38° F., 7 a. m. Wind north. Clear. Boxes unchanged.

December 3.—Temperature 56° F., 9 a. m. Cloudy. Wind north.

December 5.—Temperature 44° F., 7 a. m. Clear. No change in boxes.

December 6.—Temperature 44° F., 7 a. m. Wind south. Partly clear.

December 7.—Temperature 44° F., 7 a. m. Wind southwest. Partly clear.

December 8.—Temperature 42° F., 7 a. m. Cloudy. Wind north.

December 9.—Temperature 42° F., 7 a. m. Cloudy. Wind north.

December 10.—Temperature 42° F., 7 a. m. Clear. Wind north.

December 11.—Temperature 44° F., 7 a. m. Cloudy and mist. Wind south.

December 12.—Temperature, 55° F., 8 a. m. Wind S. Cloudy. Boxes unchanged.

December 13.—Temperature, 62° F., 8 a. m. Wind S. Misty. Thunder at night

December 14.—Temperature, 60° F., 8 a. m. Wind NW. Drizzling rain.

December 15.—Temperature, 30° F., 8 a. m. Wind N. Clear.

December 16.—Temperature, 30° F., 8 a. m. Wind N. Clear.

December 17.—Temperature, 32° F., 8 a. m. Wind N. Clear.

Transferred box No. 11 to my room, where a warm temperature is maintained.

December 18.—Temperature, 44° F., 7 a. m. Infusorial life active about sunset.

December 19.—Temperature, 54° F., 7 a. m. Wind SE. Cloudy. Rain.

December 20.—Temperature, 64° F., 7 a. m. Wind S. Rain.

December 21.—Temperature, 60° F., 7 a. m. Wind W. Drizzle.

Examined my boxes closely; chrysalids apparently sound. The temperature has not been high enough to effect transformation into moth.

December 22.—Temperature, 38° F., 8 a. m. Wind N. Clear.

December 23.—Temperature, 35° F., 7 a. m. Wind N. Cloudy.

December 24.—Temperature, 37° F., 8 a. m. Wind N. Cloudy.

Examined Mallow leaves and found Aphides living.

December 25.—Temperature 44° F., 8 a. m. Wind SW. Cloudy

December 26.—Temperature, 50° F., 8 a. m. Wind NW. Drizzle.

December 27.—Temperature, 42° F., 8 a. m. Wind W. Clear.

December 28.—Temperature, 52° F., 8 a. m. Wind SW. Clear.

December 29.—Temperature, 48° F., 8 a. m. Wind N. Clear.

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December 30.—Temperature, 40° F., 8 a. m. Wind W. Clear.
One parasite, *Pimpla conquisitor*, in box No. 11.
December 31.—Temperature, 45° F., 8 a. m. Wind W. Clear.

To summarize: Have placed in box No. 1, 54 chrysalids. Transferred 9 to No. 3 box. Twenty-seven came out as moths and one parasite, leaving 17 chrysalids in that box, which on last night was upset by a wind and contents lost.

In No. 2, glass jar, placed 23 chrysalids. Eight have issued as moths and one a parasite, leaving 14 chrysalids.

In No. 3, glass jar, a number of eggs. These have become darker, but otherwise appear to be unchanged.

In box No. 4 placed 13 chrysalids on October 12. On November 9 introduced 60 chrysalids, making aggregate 73. Introduced, November 17, 25 chrysalids, making sum total 98. Removed 19 dead moths November 28, leaving 79 chrysalids.

Placed a number of moths in box No. 5 on October 15. Of this lot 60 moths were out by November 2. On November 17 introduced 25 chrysalids. On November 28 removed 20 dead moths, leaving a number of chrysalids. There was no development in the last 25 chrysalids placed in the box.

Put up a number of chrysalids in glass jar No. 6 October 15; 3 moths came out by 31st; 4 dead moths removed on November 28. No further developments. Put up 101 chrysalids in No. 7 glass box (vivarium), October 20. These developed into moths slowly up to November 3, when they commenced to die, and all were dead on the November 28, when I introduced 40 fresh chrysalids. At this date, January 2, 1882. some of the eggs retain their green color, while with the larger number the color is slightly darker brown. From my observation, this as well as previous seasons, and from the difficulty of procuring nectar by the last brood of moths, and their consequent ill condition for hibernation, I conclude that Aletia is to be classed with that family of moths that do not hibernate as imago.

October 21, put up 61 chrysalids in box No. 8. No development in this box until 2 dead moths were discovered in it on November 28. It remains in *statu quo*. November 5, arranged box No. 9 and placed in it 90 chrysalids. There has been in this box no development to this date, January 2, 1882.

Same date, arranged box No. 10 and placed in it 140 chrysalids; no development in this box to date. The three last boxes, Nos. 8, 9, and 10, have been placed where they have been subjected to atmospheric conditions, and have been kept damper than those in the house, and consequently the transformation of the chrysalids has been retarded.

On November 9 put in box No. 11, 60 chrysalids; on November 18 there were 20 living moths; on November 21, 10 dead and 11 living; on November 28 all moths dead; 39 chrysalids left in box; on November 30, 1 ichneumon, *Pimpla conquisitor*. On November 28 put up in box No. 12, 80 chrysalids, brought in on November 21. No development to date; chrysalids looking fresh and sound.

On November 29 put up in glass bottle No. 13, same date, a few chrysalids. No development; chrysalids looking sound. There has been an exceptional absence of parasites this season. I shall expect a larger proportion from the chrysalids on hand.

By a review of my report you will perceive that I have a large number of chrysalids subjected to various temperatures and conditions, such as to afford a good test for ascertaining whether and how Aletia hibernates or survives the winter in this latitude.

I shall likewise, in due time, report to you upon the Malvaceous family of plants in this locality, furnishing you with list of same, and list of those of the State, as far as lies in my power, and will prosecute search for Aletia larva in same.

Hoping that my researches may prove of some interest to the Department, and desiring a continuance of the work, I have the honor to be,

Yours, truly,

E. H. ANDERSON, M. D.

Prof. C. V. RILEY.

REPORT FOR 1882.

KIRKWOOD, MISS., *October* 16, 1882.

SIR: I have the honor, by virtue of my commission from the Department, to make to you the following report of my work, under your instructions, for the quarter ending September 30, 1882.

It must to a great extent appear to you a recapitulation, as I have from time to time forwarded you reports; but, by your request, embody the whole time in the report now submitted, with a voluntary supplementary report up to this date, October 16, 1882.

In my visits of observation, from the 1st to the 8th of July, found cotton from 15

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inches to 3 feet in height and growing luxuriantly, the preceding month having been of high temperature and seasonable, and consequently favorable to the growth and cultivation of the plant. I found Aphis abundant in spots, but not generally so. Ants in usual numbers, and chiefly among colonies of Aphis. Found a few forms cast from shedding, but no evidence of either Aletia or Heliothis. On the 8th a chrysalis, wrapped up in a leaf, was found. Between this and 15th, Heliothis was found at work in the young forms and bolls, so few, however, as to require diligent search to find it. It was less observable on corn than usual up to this time. The grass worm, throughout the month, was abundant in grassy fields, both upon grass and young cotton and corn, destroying all in many instances, and not confined to bottom, but appearing on hillsides as well. No other development of interest until the 24th, when a full-grown Aletia larva was brought in from the field, which passed into chrysalis and emerged August 4.

Through correspondence learned that larvæ three and four days old were discovered near Canton, same date; other larvæ seen here about same time. Heliothis also seen flying about. Noticed Aphis upon okra contiguous to cotton in same numbers as on cotton; also circular perforations, apparently the work of a cotton-leaf worm.

Have looked carefully after plants of Malva family during spring and summer, but so far have seen no trace of Aletia.

A notable fact has been the sudden disappearance of the Grass Worm after a heavy rain. I have often noticed that Aletia does not appear in considerable numbers during a spell of wet weather, whether stormy or not, and believe that such heavy rains as we have had recently, by lowering the temperature and washing them off, would retard their progress.

The mean temperature has been 10° Fahr. less than that of June. Facts so far would seem to indicate that Aletia had struggled through in some form from its departure last fall until its advent this summer.

Continued my visits to different fields of cotton to watch progress of both Aletia and Heliothis. Found very few, though every field has had its quota. Atmospheric conditions have not been favorable, or else the third brood would be easily discoverable, if not damaging. The mean temperature has been much lower than usual, ranging from 70° to 82° Fahr. Have had frequent showers throughout the month, succeeded by cool spells, northwest and north winds prevailing, and hard rains on 23d, 24th, and 25th, lowering temperature.

Heliothis has been at work, but to a less extent than usual. Noticed its absence in early corn, and, in fact, could find no sign of it in the first planting, though the Grass Worm was much more abundant than usual. In the corn planted in May it (Heliothis) is now out in full force; in fact, in a small field of my own, planted in May and now in milk stage, it may be found in every ear, and has done considerable damage. On the 15th, while walking at dusk along a field of cow-peas, where I had gathered a crop of early corn, I noticed numbers of a small, gray moth in the grass and a like number of Heliothis about the peas. I have repeated my visits since, and from the numbers of moths and larvæ found there have come to the conclusion that it relishes that food as well as corn or cotton; and it has suggested to me that by planting an early crop of corn and a crop of peas in the corn, so timing the planting that the peas shall be in bloom about the time the corn hardens, and planting a later crop of corn and peas, so as to furnish food for the season, Heliothis would be kept out of the cotton. Suggestions as to corn have been made by others (see pages 312, 313, Report on Cotton Insects, 1879), but inasmuch as the pea crop continues to bloom and make fruit so much longer than corn it would furnish food for the whole season.

I shall watch my crops of peas in reference to Heliothis, and will report to you the results.

Received the pyrethrum the 22d, and made my preparations by adding 1 ounce pyrethrum to 10 of flour and 1 to 30 of hot water. I used hot water to make a decoction, as recommended by Professor Hilgard, and to prevent fungus, as referred to by Mr. Schwarz, when made with cold water, thinking the heat would destroy the fungus germ. Will try it likewise with cold water.

Tried the dry preparation on grown and young Boll Worms on the 24th. The powder was apparently slow in having any effect, though it seemed to stupefy the older worms, while putting the younger in a torpid condition. I allowed them to remain twenty-four hours, sprinkling the powder heavily upon them and the leaves, inclosed in a small bottle, when, on examination, I found the small ones dead and the larger active. The infusion soon put the larger ones to writhing, the smaller remaining torpid and quiet. In an hour the larger and intermediate size commenced crawling, when I reapplied the solution and they again became torpid after writhing a few moments, and died in thirty-six hours. On the 25th brought in a fresh supply of worms, and after adding ½ an ounce of pyrethrum to each preparation, applied the dry to a lot of Boll Worms of various sizes, all of which were soon under its influence, writhing and becoming torpid, the smaller soon killed outright, the larger and full grown succumbing in from two to three hours. The result with the solution was

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similar but rather more speedy, as all were dead in a few hours. Placed some of the worms in a quinine bottle, recently emptied, and three young worms died in a few minutes. Tried a solution of quinine, 1 grain to 1 ounce of water, 2 minims of elixir of vitriol. This seemed to worry, but did not kill.

26th. Applied the infusion, when they soon commenced writhing and then became torpid; ate nothing; but found three alive on the 28th, one very large, the other two middle size. Made another application of this infusion prepared on the 22d, which still appears to be strong, but shows plainly fungus. Made fresh solution with cold water, 1 to 30; applied that to 8 caterpillars, Heliothis, all sizes. Have also applied powder made on 22d, to a lot, all sizes. The powder is kept in a box tightly stoppered. Have reviewed circular in reference to pyrethrum, issued by the Department last year. Will here mention that I planted the seed with care, as other annuals, but while they grew luxuriantly but three of the pyrethrum seed germinated, and eventually died out, owing perhaps to too much wet. If the Department will send me a paper of seed this fall or next spring, I will plant them on a bluff near my spring, where it is rocky and dry, with a loamy, sandy soil, and where there is shade enough to protect from heat in summer. This will approximate to some extent its native habitat.

29th. On examining the three worms to which the solution was applied yesterday, found the two smaller dead, the larger one alive. Of the eight to which the fresh solution was applied found the four smaller dead, the larger one living. Of the six to which the powder was applied, after temporary writhing, they became torpid, but found all alive. Have reapplied both powder and solution. All cease to eat after making any application.

30th. Found all to which the application was made yesterday dead except one large one. Applied solution to another lot after noon.

31st. Found my caterpillars apparently unaffected by the application of yesterday. Have applied to them cold infusion made with cold water, 1 to 24. Brought in a fresh lot, to which I have applied fresh solution, and also powder prepared with fresh ashes, 1 to 8. Am satisfied that Heliothis is tougher and less sensitive to applications than Aletia, and requires a stronger preparation. The ashes would recommend itself on account of cheapness, and can be manipulated better, and as an alkali would tend to check fungus. In regard to solution, would think hot water better than cold, but when immediately used it would make no difference, as the powder mixes as well with one as the other.

The above experiments were made as a necessary preliminary to my field operations, as I was unacquainted with any results with pyrethrum upon the Boll Worm.

From the number of Heliothis now in late corn, I infer considerable damage from them in the late cotton. Atmospheric conditions since the 20th of August have been far more favorable for insect life than previously, yet the temperature remains low for the season, about 76° F. mean temperature, range from 70° to 82° F. Aletia has made slow progress, but is observable now everywhere.

September 1. The worms to which the cold infusion was applied yesterday were found quiet morning, all dead afternoon. Those to which the powder was applied also died within thirty-six hours; applied same powder to another lot.

September 2. Found them quiet but alive this morning.

In continuing my report for this month, will state that the weather in the early part of the month was very unfavorable for field work, owing to rains; and owing to meteorological and other causes, Heliothis could, only with difficulty, be found in cotton at all. I traversed field after field of cotton in search of it, with a view to commence experiments, but could nowhere find them in any number that would warrant experiments for practical use. As an evidence of their scarcity I will mention that I counted along two parallel rows, one hundred and five stalks of cotton, very luxuriant and in bottom land, full of forms and bolls, and found but one small Boll Worm and two small bolls punctured. This furnishes an average of many examinations made with care. It is a common remark made by planters in my locality that "there are no Boll Worms this year." Had I not examined corn would have come to the same conclusion. My observation this season would certainly lead me to the conclusion that corn is its preferred food, for nowhere have I examined corn in the milk stage without finding one or more in every ear.

September 14. Examined a field of luxuriant cotton, rows running parallel with corn. Found no Boll Worms in cotton, but one in every ear of corn. They were full grown. On examining hard corn found no worm, but at the base of the stalk found the aperture where it had gone into chrysalis, and as there were no peas there, it will in the next brood, no doubt, be found in the cotton and will furnish a field for experiment. My conclusion is that this, the third, perhaps the fourth, brood is now in chrysalis, and will, later in the season, be out in large numbers in cotton except where corn or peas are near by. I have used the pyrethrum mixed with flour one to ten, by dusting it on the silk and opening slightly and introducing a small quantity into

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the apex of the ear, and on examining the following day have found the worm missing. It drives it out, if it does not kill it.

I have used it on pea vines in infusion 1 to 30 by spraying, but cannot as yet report accurate results, although it is certain that its use diminishes the visits of insects of various kinds that frequent them for nectar. Finding myself foiled in prosecuting experiments implicitly, according to instructions, I have endeavored to study its habits where I have found it, hoping to place at your disposal some simple and feasible plan of preventing its ravages in cotton. Recent observation has strengthened my belief, as intimated in a former report, that they prefer peas to cotton; and it would seem very natural, if they do eat peas, that as after leaving corn they go into chrysalis at the foot of the stalk, when they emerge as moth they would commence upon the nectar of the pea, right at hand, and there also incubate, as the pea furnishes food for its larvæ. As the pea continues to bloom throughout the season, when visited by occasional showers, it would there find a continuous and inexhaustible supply. This plan would not only be within reach of ever farmer, but would add to his food supply and prove a blessing. I shall continue my visits daily to the field, and will commence spraying, under instructions, as soon as the worm makes its appearance; and, judging from past experience, it will not be long before the larvæ will be out in full force.

As the season has been so unpropitious I will here offer to continue experiments to the 15th October, without salary for that time. I will here remark that all the usual insect visitors of cotton are less numerous than usual. The effect of Aletia is nowhere visible, though a few may be found in any field. A later brood may strip the cotton, but will be too late to do any damage. The season has been characterized by low temperature, but abundant moisture, proving that high continued temperature, as well as moisture, are essential to the propagation of these two Noctuids. The fact that there has been a succession of corn crops and abundant pea crops this season and an absence of Boll Worms in cotton corroborates the belief that Heliothis prefers the former to the latter as food. Having failed to find Heliothis in cotton in sufficient numbers for experiment, on the 18th I transferred 12 small larvæ from corn to cotton. On the following day sprayed the stalk with an infusion of pyrethrum 1 to 30, cold. On the 20th found 6 of the number nibbling; on the 22d and 23d but 2, and on the 25th but 1. Could see do damage done by them and no sign of them upon contiguous stalks. Examined the field of cotton referred to as having been visited on the 14th; there found on cotton adjoining corn eggs of Heliothis, both on leaves and outer calyx, and young worms. Will commence operations there in a day or two. As there were no peas there the moth, as predicted, on emerging at the base of the corn stalk, sought the cotton. A search for them elsewhere in cotton has proved fruitless.

27th, marked off plat 16 yards square and applied infusion, cold, 1 to 24, by spraying with force pump (Rumsey & Co., patentees, Seneca Falls, N. Y.). I so direct the nozzle as to apply it chiefly to the under surface of the leaves through a fine spraying nozzle. This piece of cotton was selected, as I there found a number of young Boll Worms, eggs, and also Aletia; October 2, sprayed a plat of cotton 10 yards square, upon which I found a few Boll Worms and Aletia; the cotton was adjoining corn. Aletia larvæ, half grown, showed the effects of the poison almost immediately, and after writhing for a short time fell to the ground. Half grown Boll Worms seemed less sensible to the effects, but left the boll and ceased to eat. This infusion was 1 to 30, cold, and applied fresh.

October 3, visited the field where I had previously used solution and dusted cotton with flour preparation and found no sign of worm either where I had placed the worms or upon adjoining stalks. As pyrethrum kills by contact, the infusion is greatly to be preferred, as, by means of a spraying pump, it can be made to reach every part of the plant. I would suggest the use of tanks, rather flat than otherwise, so that the pump when on a wagon would be but little above the top of the cotton, and should be directed rather against the cotton than over it. The spray striking the plant laterally reaches the under surface of the leaves more readily.

Looked diligently for Heliothis in cotton remote from corn, but could find none.

October 4, visited a field where I found a few Aletia and here and there a Boll Worm. Applied to cotton the flour preparation, 1 to 10, which has been kept in a close box for several weeks, and find it as efficient as when first prepared. Aletia gave evidence of its effects at once, and ceased to eat, and after a few contortions spun a web and dropped to the ground. The Boll Worm is more quiet under its influence, a difference perhaps in constitution, but soon becomes torpid and ceases to eat.

A close examination of a field of cotton which has both bottom and upland and is in vigorous growth, though of a russet aspect, partly from rust and partly from season, and which is an average specimen, shows less injury from both Heliothis and Aletia than for many years past, yet in many crops there is a loss of middle crop due mainly to shedding.

October 7, sprayed a plot 20 feet square with an infusion, 1 to 24, cold. This had upon it a large number of well-grown Aletia larvæ, but some of all ages. This plat

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adjoined cotton on one side eaten bare, on the other almost untouched. My object was to see whether I could stop their progress, moving as they were from west to east. Have long held the opinion, confirmed by observation, that it never leaves the stalk upon which the egg is deposited to eat again. I there saw them crossing a public road, leaving behind untouched cotton.

October 10, examined cotton where I had previously dusted flour preparation and found that no progress had been made in injury to the leaves, though found a few young caterpillars; also, examined cotton upon which I had placed Boll Worms removed from corn, but found no damage. My belief is that when transferred from one plant to another they are either slow to eat or do not eat at all. Examined the field sprayed on the 7th and found some worms still there, but a comparison with adjoining cotton showed that the pyrethrum had destroyed many.

14th, examined the plot sprayed on the 2d instant, and found that undisturbed by worms of any description, and found some dead worms upon the stalks. This plat had also a fresher appearance than any surrounding cotton and was free from worms, while Aletia could be found all around it.

I will remark that the result upon pea vines, where the infusion was applied, was exemption from worms, but at the same time must confess that I saw no damage elsewhere. Though finding many leaves perforated, I did not find Heliothis larva upon the leaves or pod, but occasionally found other caterpillars.

To sum up, would say that, from my experiments and experience with pyrethrum, if sprayed over cotton or dusted on the apex of the ear of corn so as to reach the worms, in infusion or decoction, cold or hot, in the proportion of one pound to thirty gallons of water, or one pound to ten of flour or ashes, it would effectually protect cotton against either Heliothis or Aletia; but a stronger preparation, say one to twenty-four gallons or one pound to eight pounds, would be more efficient, especially for large Boll Worms. After being once touched with it, I think they cease to eat, sicken and die. I would prefer always the spraying to the dry powder, for the reason that it can be more generally diffused over the plants; and furthermore, because it disturbs the worm and would, in many cases dislodge it from the plant, and when once dislodged or disturbed they seem to wander distractedly.

As before remarked, Heliothis has not visited here in its wonted numbers in cotton, and unless it has sought other vegetation, adverse meteorological conditions have been in operation.

I believe, however, successive crops of corn and peas, which have been a feature of farming this season, may account for its absence in cotton; and from this a hint may be taken, which, if put in practical operation, would insure the cotton crop against damage from Boll Worm. Either hand-picking or the use of pyrethrum with the first brood in corn would be a feasible operation with any planter.

I would also say, unhesitatingly, that any farmer, by the use of pyrethrum or other poisons, can, by watching the advent of the first brood of worms, which almost invariably occupies a small area, stop its ravages by a timely application, and at a small outlay of either labor or money.

Respectfully submitted,

E. H. ANDERSON, M. D.

Prof. C. V. RILEY

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APPENDIX V.

COTTON CATERPILLARS IN BRAZIL.

By John C. Branner.

[Extracted from a manuscript report on cotton in the Empire of Brazil—an account of investigations made by Mr. Branner and Mr. A. Koebele, during a trip made to Brazil in the spring of 1883, under direction of C. V. Riley.]

HISTORICAL.

That there were caterpillars that destroyed the leaves of the cotton plant was known to the earliest settlers of Brazil. In the *Roteiro do Brazil*,* written between 1570 and 1587, Gabriel Soares de Souza, in speaking of the kinds of caterpillars in the province of Bahia, says: "Some of them destroy the young mandioca, *cotton*, and rice, and injure the sugar cane, and sometimes there are so many of them that the roads are full of them, and they leave the ground over which they have passed clear of grass and parched."

In 1794, Dr. Manuel Arruda da Camara, naturalist in the service of the King of Portugal, wrote, at Pernambuco, his treatise upon cotton.† In Chapter VII of this work he treats of the diseases peculiar to the cotton in Brazil, and of the insects affecting it. The following is what he wrote upon the caterpillar:

"There are caterpillars proper to the cotton plant, which live upon its leaves, and which are so voracious, and appear in such numbers in certain years, that in a few days they eat up a whole cotton plantation, gnawing even the tender shoots so that the plants appear to have been swept by fire. These insects go through their whole metamorphosis within twenty days, a little more or less; that is, up to the last metamorphosis, called by botanists the *imago revelata*. This plague does great damage to the young plants, for they eat them off almost even with the surface of the ground, because they find the trunk still tender. They do not fail to injure the grown plant seriously also, especially when freshly flowered, for their fruit does not come to perfection, and it is difficult for them to take on new foliage. Sometimes, however, when, after having eaten for some days, a heavy rain falls on them that knocks them to the earth and kills them, the cotton plants put out lateral branches which produce an admirable quantity of fruit, and thus they serve the purpose of a pruning. The caterpillar does not generally come, save in the season of the early rains, commonly called the 'first waters.' For the same reason they are called 'papillon printanier' in Cayenne and San Domingo. If these first rains are followed by continuous sunshine or by a few light rains, these caterpillars appear in great abundance; but if the rains continue abundant and heavy, those that have appeared perish, and new broods are prevented. On account of the close winters it is now three years since they have been seen."‡

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* *Revista do Instituto Historico do Brazil*, 1851, p. 268.

† *Memoria sobre a Cultura dos Algodoeiros*, por Manuel Arruda da Camara.

‡ In these two accounts alone we have sufficient evidence of the existence of "Cotton Worms" in Brazil since the first settlement of the country by the Portuguese. In the Department of Agriculture Report (1879) on Cotton Insects, pp. 74 and 358, a writer is quoted as saying that Cotton Worms were never observed in São Paulo prior to 1863, and that after cotton began to be extensively cultivated they appeared in such numbers as to cause the culture to be nearly abandoned in 1874.

A glance at the statistics of exportation from the province of São Paulo shows that while cotton only began to be exported about 1864, the exports in 1873–'4 were larger than in any year before or since. The natural explanation therefore is that when the planters took no interest in cotton culture, caterpillars never troubled them, but in proportion as the culture grew, the ravages of these insects attracted increased attention from them.

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Koster, whose *Travels in Brazil* cover the period from 1809 to 1815, in speaking of cotton culture in the northern provinces says:* "The profits which are obtained in favorable years by the planters of cotton are enormous; but frequently disappointments are experienced. Oftentimes a whole crop is totally lost, and, instead of large returns, the year proves entirely unproductive; or, after a fair promise, the grub, *the caterpillar*, the rain, or the excessive drought, destroys all hope until the following season."

Referring to the cotton plants in the province of Minas Geraes, Auguste de Saint-Hilaire says:† "Ils ont un ennemi redoutable; c'est une chenille arpenteuse qui en mange les feuilles, et fait beaucoup de tort." In a foot-note he adds:‡ "J'ai conclue qu'elle était arpenteuse, de la description qu'on m'en a faite, car je ne l'ai point vue. Serait-ce le *Noctua gossypii* Fab.?"

Mr. Lyman says:§ "Along the coast the climate is unfavorable, and the ravages of insects are such as to make the cotton crop very uncertain."

Dr. Antonio Rego, in his *Almanack do Povo para* 1867, in speaking of the drawbacks to cotton raising in the province of Maranhão, says:‖ "The development of cotton growing is subject to certain drawbacks, among which are * * * insects, such as the caterpillar, and others less injurious." * * *

Dr. Burlamaqui, the then secretary of the Sociedade Auxiliadora da Industria Nacional at Rio de Janeiro, wrote a monograph upon the cotton plant in 1863, in which he says:¶ "The *Noctua gossypii* caterpillar of the cotton plant generally lives alone, but it often forms part of numerous swarms. Then, as if they had been convoked to give the planter a lesson, they march in close columns, enter the cotton field, and in less than twelve hours destroy the leaves and flowers and the tender capsules and young twigs. This destruction may be recognized at a great distance by the odor of the droppings. As soon as one cotton field is destroyed they march to another, destroy that, and so on. Fortunately, however, the number of caterpillars gradually decreases, for many of them passing into the chrysalid stage, bury themselves in the earth. These attacks do not occur every year, or at fixed periods."

Dr. Miguel Antonio da Silva has the following reference to caterpillars that injure the cotton plant:** "The plantations are exposed * * * to the attacks of divers enemies. The most relentless of these are two species of *noctuellas* (*noctua subterranea* and *noctua gossypii*), the latter of which, in the larval state, often despoils the plants of their foliage, flowers, and fruit in the space of twenty-four hours!"

These brief references constitute the literature of the subject of the Cotton Worm in Brazil; and it should be borne in mind, at the same time, that there is nothing to indicate that Dr. Burlamaqui and Dr. Silva knew of the existence of such insects in that country.

Outside of the cotton-growing districts one never hears of them, even though he make the most careful inquiry, unless perchance he encounters a planter of cotton or a resident of the cotton-growing region.

In 1871 the *Novo Mundo* published a short article upon the Cotton Worm in the United States. With reference to this subject in Brazil, the article says:†† "Up to the present it does not appear that the cotton plants in Brazil have suffered much from the insect proper to them." These remarks received the indorsement of the editor of the *Auxiliador da Industria Nacional*, the leading authority on agricultural matters in Brazil, to such an extent as to be copied in that journal‡‡ in 1878, together with the very poor illustration that accompanied the original article, a fact which would indicate that it is not generally known, even to-day, that the caterpillars do serious damage to the cotton plants. And such indeed is the case.

Although diligent inquiry was made at Pará, Maranhão, and Pernambuco, no one was found who had any knowledge of an insect injurious to the cotton plant. In the last-mentioned city I hoped that the agricultural society would be able to furnish

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* *Travels in Brazil*, by Henry Koster, vol. ii. p. 172; 2d ed.

† *Voyage dans les provinces de Rio de Janeiro et Minas Geraes*, par Auguste de Saint-Hilaire (1817–'18), vol. ii, p. 108.

‡ This note was made in 1817–'18.

§ *Cotton Culture*, by J. B. Lyman, p. 154.

‖ *Almanack do Povo para* 1867, *por* Dr. Antonio Rego, Maranhão.

¶ *Monographia do Algodoeiro*, pelo Dr. F. L. C. Burlamaqui, Rio de Janeiro, 1863, p. 56. It should be remarked in regard to what both Dr. Burlamaqui and Dr. Miguel Antonio da Silva say in regard to Cotton Worms, that it is not clear that they refer to caterpillars as being found in Brazil, and the fact that their writings upon cotton are largely compiled from writers upon cotton in other countries would strengthen this doubt. But such cannot be said of any of the other writers quoted.

** *Revista Agricola do Imperial Instituto Fluminense de Agricultura*, No. 5, Sept., 1870, p. 12. *Vide* also foot-note on preceding page in regard to Dr. Burlamaqui's remarks.

†† *O Novo Mundo*, May 24, 1871, p. 123.

‡‡ *Auxiliador da Industria Nacional*, 1878, pp. 159–160.

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some definite information upon this subject, but none of the prominent members in the city knew of such insects. In Bahia alone, after having finished the field-work, did I find one gentleman, Dr. Antonio de Lacerda, who had, at the request of Prof. C. V. Riley, bred one of the moths from a caterpillar found upon a cotton plant in the suburbs of that city.

OBSERVATIONS.

The time of the appearance of the caterpillars depends upon when the first rains of the winter season set in, and their abundance or scarcity depends upon the regularity or irregularity of the rains. They appear at the setting in of winter every year in greater or less numbers, but it is the universal testimony of cotton planters that the seasons in which winters set in early, and in which one, two, or three weeks of rain are followed by from a week to a month of sunshine,* are the ones in which the caterpillars do their greatest injury.†

As has already been observed, the beginning of the rains is not perfectly regular, as it sometimes varies a month or two one way or the other. In the province of Pernambuco, and through those provinces which border upon it, it is generally expected that the caterpillars will do their greatest injury during the months of April or May, for it is generally in these months that there is a temporary cessation of the regular winter rains. They appear, though, in small numbers much earlier, even in the month of January,‡ and it is possible that in some localities and under circumstances favorable to them they may do great injury as early as that month. If, however, the rains of the early part of winter are regular, and there is no interval of dry weather, caterpillars will not appear in numbers sufficient to do any serious injury to the cotton crop.

The duration of this pest also depends upon the weather; that is, upon the length of the *veranico*, or short, dry season. To the difference in the length of the *veranico* is probably due the difference in the duration of the caterpillars as given by the answers to the circular. According to these answers the length of this short, dry season varies from one week to three months.

It is the universal testimony of the planters that when the regular heavy rains of winter begin, the caterpillars disappear. If, however, the rains do not come on shortly after their appearance, the plants are completely defoliated, and even the tender twigs, the young bolls, and sometimes the tender bark of the plants, are devoured, leaving the field as bare as if it had been burned. It is said that when they appear in large numbers, one can hear the sound of their gnawing the leaves, and their excrement emits a characteristic odor which may be distinguished at a considerable distance.

No observations that can be relied upon have been made in regard to the kinds of soil on which the caterpillars first appear, or which they prefer or avoid. I have been told by several persons that they are not so likely to appear in fields newly planted, and which have just been burned over, a fact which they attribute to the presence of the ashes on the soil. Some affirm also that they prefer high ground, others that they prefer lowlands; some say rich and some say poor ground. The only indication that they prefer plants growing upon good soil is the fact that the planters of São Paulo planted their cotton on poor or wornout lands, rather than expose it to the ravages of the caterpillars on the best soil.§

During the stay at Bonito, in the province of Pernambuco, we first found the eggs and larvæ on the lower and more moist ground; later there seemed to be no appreciable difference in the numbers found on low or high ground.

It is said that the younger plants are the ones that suffer most from the ravages of those insects, and when they appear shortly after the cotton has started from the ground, they eat the plants up entirely, and render replanting necessary, while the plants already grown, and above all the old tree-cotton plants, suffer comparatively much less. The injury done the young plants is so great in some parts of the country that, rather than run the risk of losing their whole planting, cotton growers do not plant at the beginning of, or before, the rainy season sets in, but wait until the end of the short, dry season, or till the time of danger is past.

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* This season is called *veranico* (diminutive of *verão*—summer) in the Portuguese, and corresponds to our Indian summer.

† Such weather is favorable to the appearance of all hibernating insects in Brazil. When the rainy season sets in insects come out at once in large numbers. They are, therefore, most abundant in March, April, and May, and during those months they are often very annoying at night, flying into rooms, when attracted by lights, in great numbers. When we reached Bonito, in the province of Pernambuco, in the early part of January, insects were comparatively very scarce, and when we left, toward the end of February, they were much more plentiful.

‡ The first eggs and young caterpillar were found by Mr. Koebele at Bonito, in the province of Pernambuco, January 8, 1883.

§ This note was taken by Mr. W. T. Gepp in the province of São Paulo in 1876, from a prominent planter.

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THE TWO SPECIES.*

So far it has not been attempted to distinguish between the two species of larvæ that affect cotton-plants in Brazil. As a rule, the people of the cotton region call them all "cotton caterpillars," and I saw but one person, a farmer, who, when the two larvæ were shown him, recognized the fact that they were different, and who assured me that the *s* was the "true cotton caterpillar," as he called it. The *b* species, he said, also devoured the cotton, but they never seemed to be so plentiful. How much credence is to be given to this statement, it is impossible to say, until further observation shall have been made.

It is not to be expected that the planters would observe carefully the first appearance of the larvæ, or that they should notice their presence at all until they become dangerous; and such is the case. This also explains their assertions that the worms appear in April and May. Up to the 22d of February the planters about Bonito insisted that there were no caterpillars in the cotton-fields, although they had been found by us for more than a month.

At Bonito, January 8, 1883, the eggs and young larvæ of *b* were first found, and the first moth came out January 23. The collecting in the field was continued from January 8 till February 22, and the moths were bred as rapidly as possible. But it was not until the 6th of February that *s* came out, just two weeks after the appearance of the first *b*.

Up to February 22, there were, in all, about 559† specimens of these moths bred. Of this number only 48 were *s*, all of which came out between February 6 and February 22. Aside from these that were bred indoors, either from larvæ one or two days old, or from the eggs, there were only three *s*, and twenty-two *b* captured. Every effort was made to capture both kinds of moths, but baiting and the use of lights to attract them were quite unavailing. A few *b*'s were taken along with large numbers of noctuids‡ that frequented the flowers of the *Cleome heptaphylla* that grew abundantly about our house. Out of the 25 thus captured, only three were *s*.

The eggs from which the moths were reared were found on the inferior sides of the cotton leaves, while the larvæ were taking by beating the bushes, none of them being rejected.

The eggs and young larvæ when taken were placed in breeding cages together, and fed until they pupated, when the pupæ were removed to other boxes. It was noticed that the *s*'s generally webbed up in the gauze covering of the breeding-boxes, while the *b*'s preferred the bottom of the boxes and the cotton leaves or bits of paper placed there for them.

The time passed in the pupa state appears to be the same with one as with the other species. Of the 143 observations in regard to the time from the day of pupating till the issue of the perfect insect, 108 were made upon *b*, and 32 upon *s*. In the case of the latter, the insect remained in the pupa state as follows:

Days in the pupa:	Cases observed.
11	14
10	5
12	5
13	2
14	1
16	1
9	1

In the case of *b*, the time passed in the pupa state was as follows:

Days in the pupa:	Cases observed.
11	44
10	27
12	24
9	6
8	5
13	1
14	1
16	1

* Of the insects here referred to, those marked *b* include a very variable species, which is *Anomis derogata*, while those marked *s* are the genuine *Aletia xylina* (Say). For further particulars see note (58).

† Fifteen others were bred at Bahia, of which three were *s*.

‡ Mr. Koebele, unaided, caught in the cyanide bottle more than a hundred moths on the *Cleome* flowers almost every night after February 8. One evening he caught 228, another 228, and another 439. These moths were taken between 8 and 11 o'clock, after which hour but few were seen. On several other evenings he caught over 200 in the same manner.

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In all cases where the insect remained in the pupa more than twelve days, the pupa had been kept in a close, glass-covered box, which was badly ventilated, or not ventilated at all.

The weather was, during this time, for the most, rather cool for the time of year.

The moths came out generally between 7 and 9.30 o'clock in the evening, though a few came out a little earlier, and quite a number, especially toward the last, issued as late as 2 o'clock in the morning.

Broods.—Time did not permit extended observations in regard to the number of broods. From what is known of the habit of the insect in the United States, and the time of its first appearance in Brazil, say January 1, and the time when the plague is said to end, say June 15, the number of broods can readily be estimated. In case the suspension of rains at the beginning of winter lasts longer, of course the number of broods will be greater. As the climate of Brazil does not admit of winters sufficiently cold to kill the pupæ, the numbers that survive the rains and the accidents of hibernation must be very great.

On the other hand, the comparatively uncultivated fields in which cotton is grown tend to favor the number of insect enemies of the cotton insects. On almost every cotton plant numbers of spiders, beetles and ants were found. Sometimes a dozen or more empty egg-shells were found upon a single plant, and the most careful search would not discover a single caterpillar, either large or small, while a few small, transparent spots in the leaves would show that the young larvæ had been there, and were probably devoured by some of their enemies. The plants are too high for domestic fowls to be of much service in devouring them, but the planters say they are eaten by all kinds of wild birds.*

REMEDIES.

The preventive measures and remedies recommended by Burlamaqui are as follows:†

"These larvæ always spare the plantations that are full of bad grass, especially of certain kinds, like *Parthenium hysterophurus* for example. When they enter a plantation they attack the plants in the middle of it first. They keep always on the shady side, for they fear the sun, the wind, and the rain. They prefer those plants that are near together, and care but little for those that are at proper distances from each other. They never destroy a cotton-field in which the plants are far enough apart and completely free from useless plants."

In some parts of the cotton region it is the custom to replant the cotton about the time the plague is at an end, and then, by the time they have disappeared, the young cotton will have begun growing.

No direct remedy is known, and I was unable to hear of any ever having been tried. One gentleman, who was said to be an authority in regard to agricultural matters, said that he had been told that salt applied to the roots of the plants killed the insects.

When asking for some suggestion upon the subject, the answer was frequently given that nothing short of the "intervention of God" could stop such a plague when once it began.

LOSSES CAUSED BY CATERPILLARS.

In the absence of agricultural statistics it is difficult to find out the percentages of losses caused by Cotton Worms in Brazil, and whatever percentage is settled upon as the correct one it must necessarily be unsatisfactory. I was fortunate in obtaining notes made in the province of São Paulo in 1876 by Mr. William T. Gepp, of Rio de Janeiro. From a well-known planter at Itaicy in that province, who had grown cotton for a great many years, but who had abandoned it in 1873 on account of the damage caused by the caterpillars, Mr. Gepp obtained the following information, which I copy from his note-book:

"Caterpillars prefer good ground; worn lands not so subject, but the yield is only half crop." The planters were then planting their cotton upon worn ground, preferring the half crop to what the caterpillars would leave them upon better soil.

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* Birds of the parrot family, however, do great injury to cotton, especially when it is young and the bolls are tender. They often swarm into the fields and destroy the crop by gnawing into the green bolls. This is the only part of the plant disturbed by them.

† *Monographia*, por Dr. Burlamaqui, pp. 56, 57.

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The following, from the replies to the circular, shows the variety of opinions prevailing among planters in regard to the average annual losses caused by caterpillars:

Numbers of answers to circular, questions 24 and 25.	Estimated percentage of loss annually.
1	33⅓ to 50.
2	66⅔
3	33⅓
4	50
5	25
6	33⅓
8	Sometimes total.
10	25
14	33⅓
18	10

This gives an average loss of 34⅓ per cent., or say 33⅓.

The opinions and estimates here given may safely be taken to represent also those of more than a hundred cotton-planters with whom I conversed upon this subject in the province of Pernambuco.

Table showing the official value, in milreis, of the cotton exported from Brazil during the twenty-four years from 1851–'52 *to* 1875–'76, *and the losses caused by caterpillars.*

Provinces.	Official value of exports from 1851–'52 to 1875–'76.	Losses from 1851–'52 to 1875–'76.
	Milreis.	*Milreis.*
Pernambuco	142, 858, 211	71, 429, 105
Alagoas	69, 051, 267	34, 525, 633
Maranhão	72, 523, 990	36, 261, 995
Parahyba	57, 322, 080	28, 661, 040
Ceará	42, 404, 566	21, 202, 283
São Paulo	20, 715, 404	10, 357, 552
Bahia	29, 396, 222	14, 698, 111
Rio de Janeiro	19, 311, 395	9, 655, 697
Rio Grande do Norte	10, 575, 432	5, 287, 716
Sergipe	1, 747, 678	873, 839
Piauhy	2, 617, 479	1, 308, 739
Pará	542, 961	271, 480
Rio Grande do Sul	3, 164	1, 582
Total for the Empire	469, 069, 549	234, 534, 774
Reduced to dollars	$249, 545, 000	$124, 772, 500

NOTE.—The par value of the Brazilian milreis is 27 pence. But during the period covered by the table, the fluctuations were very great, owing largely to the war with Paraguay. The average rate of exchange was 26⅔ pence and the reductions are made at this average rate.

This table represents the official value of the exports previously given. It is incomplete, on account of the exports not being given for every year from some of the provinces. Neither is the cotton used for home consumption included in the amount upon which the losses are calculated.

If the losses are computed for the whole production including home consumption of cotton in the Empire for the 24 years, it gives 766,136,037 pounds as the total loss in cotton, or an average annual loss of 31,922,335 pounds.

BOLL WORM.

No Boll Worm was found in the provinces of Pernambuco and Bahia, and though careful inquiry was made among the planters for it, they agreed that no such insect was known in that part of the country. In the replies to the circulars which I sent out, a few Boll Worms are said to be found in the province of Maranhão, where they do but little injury to the cotton. Another correspondent from the same province says that he does not know of such a caterpillar. Taken together they may indicate that the Boll Worm does exist in that province, but that it rarely attacks the cotton. The answer from the province of Minas Geraes admits the presence of the Boll Worm, while those from the province of Pernambuco, with the exception of one, say that it is not known there. I have been able to find no reference to it in the writings upon cotton in Brazil.

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APPENDIX VI.

REPORT OF JUDGE WILLIAM J. JONES.

VIRGINIA POINT, TEX., *October* 5, 1880.

SIR: At no time, from the commencement of active investigations and study of the origin, habits, and destructive tendencies of *Aletia xylina*, have so many obstacles presented themselves to a full and exhaustive research into the most interesting facts growing out of the question, so very important to success of cotton growth in the South. During the season just passed, through the whole length and breadth of the land where cotton has been cultivated (except in a few favored localities), commencing early in July and not yet terminated, there has been a continuous fall of rain, unprecedented in the history of cultivation, destroying a very large portion of the crop, as yet undetermined and impossible of accurate estimate, till the remainder is secured and ginned and marketed. As far as my observation and memory date back, I have discovered in this year a more anomalous exhibit in the movement of this fugacious enemy of the cotton than before remarked in a period of forty years past. Upon a considerable number of plantations, which I was enabled to visit in despite of the frustrating conditions of the weather, I observed what I had never before witnessed, the obvious fact that in almost every field, where the fly had deposited its eggs, were plainly to be seen sections of the crop upon which no worms had appeared, although only separated by a corn-patch or turn row, while the remainder of the field was entirely riddled by these truculent depredators.

In looking for some latent cause for these special exemptions, I found in almost every instance that the unmolested spots were the early and well-cultivated portions of every field, clearly manifesting an evident instinct in the mother moth for the selection of those plants in the most succulent state and offering suitable sustenance for their *larvæ*. I found that the same views prevailed among the planters themselves as to my observations and the theory upon which they were based.

To some of the questions embraced in your Circular No. 7 * very few planters were prepared to give any answer clear to themselves or satisfactory to you. To Nos. 1 and 2 I failed to obtain any definite information. To the 3d a large number answered they had remarked no special difference. They were reminded that in 1867 and 1869, when the ground was frozen about the middle of March of each year, the fly had appeared early and the worms were very destructive. To the 4th the replies were uniform, that the worms appeared earlier and were more numerous and destructive in wet than dry weather. To the 5th, they had observed them since 1864, in some years as early as the first week in May. To the 6th, the first moths seemed always to seek the rankest cotton, which was most generally to be found in the richest land. The answers to the 7th question were varied and unsatisfactory, though a majority inclined to favor the ground hibernation, because they had plowed up chrysalids resembling Aletia, and yet few had sufficient curiosity or had taken the trouble to hatch them out. But a few of the most intelligent and observant planters were very positive they had seen the moths alive in protected spots and after the coldest weather in winter, and had no doubt in regard to identification. To the 8th question, it was answered with one accord that the insecticides most generally observed were the small ants, dispersed everywhere in the cotton fields, many varieties of birds, and some domestic fowls, where fields were convenient to habitations, assisted by spiders, wasps, yellow-jackets, and dirt-daubers, as known to plantation parlance. Among quadrupeds, none but wild animals were supposed to prey upon the worms, as hogs were fenced out and not allowed in the fields. To the 9th, opinions were about equally divided as to practical results, though a very general concurrence of views in favor of lights, if all planters would set them at or near the same time. A few had used lamps, with pans smeared with coal-tar or filled with molasses and vinegar. Hardly any were satisfied with the results, as this style of warfare was not in general use. One planter thought he had hastened the destruction of his crop, though his

* See introduction.

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reservoirs at the foot of the lights were filled with the flies, while another was equally convinced that the operations of the worms had been greatly retarded, and he was satisfied that from this cause he had fared better than his neighbors, who had not been so provident. Very many observers of the moth believed they were readily attracted by sweets, as they were generally noticed hovering about the sorghum kettles and vats in the boiling season. None had seen them feeding upon any leaf or flower. To the 11th, all answered they did not know any flowers that attracted them. To the 12th, it was stated by all questioned that they had no experience of the jute plant. One party had grown jute, but had no opinion as to its effects upon the fly or worm. To the 13th, many planters appeared to favor the use of Paris green and arsenic, while others were equally satisfied with the arseniate of soda and London purple, it being with most planters a question of cost, which decided their predilection. To the 14th, no harm need result to man or beast where caution is used in the application of any poison in solution. There was some risk when distributed in the powder. If applied in excess upon the plant, the leaves were blistered and the forms and bolls damaged. The greatest danger was in the application in wet weather, when the proportions were greatly increased. To the 15th, all expressed their preference for the poisons, though I found one old planter who had used salt (one peck to forty gallons of water), who appeared to be sincere in the belief that the worms had been killed. I saw his field about the middle of September; it had not been materially damaged, except by losses from the wet weather. To the 16th, all the answers were sheer guesses, though the lowest estimates were on the use of arsenic and London purple in solution. None cared to count the cost of the labor in the application.

After the close of my observations upon the alluviums of the Brazos and Colorado Rivers, I extended my researches to the higher and more undulating sections of the West, where the worms had worked less injury. But I was startled at the show of a large area of dead cotton. Those who owned or cultivated these lands had not the most remote conception of the causes of this moribund condition of their crops, or what would conduce to the defecation of the soil. The lands are of the richest hue, somewhat limy and adhesive, but exhibiting a wide spread of an efflorescent fungus, snuffy in appearance and equally destructive to every form of plant life. I transmitted some of this poison, spewed up from the earth in a powdered state, to your address from Werner, where I found it in large quantities.

I have made a faithful effort to experiment with the pyrethrum powders and beer mash, where there were worms working upon the cotton; but from the constant rains, even up to the present hour, found it impossible of success. None of the arsenical compounds can be applied in a cheaper and more effective form and with less waste of material than by the agencies presently in use, though there may be improvements for the more rapid distribution upon the plants. All the poisons here referred to have their advocates, while the proportions of each, necessary to cover an acre of cotton, will have to be determined by the conditions of the weather and the size of the plants in each and every locality. To cotton of an ordinary growth, in a dry atmosphere, one pound of unadulterated arsenic, three-fourths of a pound of genuine Paris green, one-half a pound of London purple, and one-fourth of a pound of arsenite of soda, to 40 gallons of water, well sprayed on, while the worms are young, will be quite sufficient for one acre of cotton. If the weather is showery, or the worms well grown, one-fourth to one-half more of the poisons may be added, depending upon the strength of the material. All these are well known and approved remedies and the methods of admixture and application are well understood.

It is impossible that the ordinary observer, without suitable aid and much waste of time, can count with certainty as to the effects of any poison upon the eggs *per se*, because many of them are barren from other causes, and if affected by poisons this could not be determined in the field; but the moment life is in the *larvæ* instinctively they begin to feed, and they no sooner eat of the poisoned leaf than they perish. The full-grown worms do not appear to be such constant feeders; they repose for hours in the day in playful dalliance with the comfort of their surroundings, are extremely sluggish till disturbed, and can not be so readily destroyed.

I found no insects affecting the root of the cotton plant nor the square or involucre within the sphere of my observation. The shedding of the squares or forms, to any unusual extent, is well understood to be due to extremes of weather, wet or dry. Nor has any insect injuring the blooms been discovered or complained of among planters, except in those localities where the Boll Worm has made its appearance. This insect has not yet reached the plantations of this section.

The views promulgated in my former report have been to some extent modified by my own observations as well as information derived from authentic sources, and I have stated them with all candor; and if a suggestion of my own opinions, upon the remedies proposed to be mainly relied on, will be of any value in the future treatment of this question, I will here make the declaration, as I am well convinced of the same, that if all those engaged in planting would consent to set lights, with pans or trays filled or besmeared with some poisonous or adhesive fluid, in the early spring, the cotton

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crops would be in a great measure protected, and this will be the speediest and surest method of destroying the mother of *Aletia*. It cannot now be doubted that without some more potent means of destruction than those hitherto relied on, to be very generally if not universally resorted to, these enemies of the cotton plant will become as numerous as the vast flights of locusts that descend only at long intervals to devour every form of tender plant life. But if suitable lamps, of simple and easy construction, supplied with a cheap burning fluid of convenient access, were supplied, I believe they would be very generally used, if they could receive the indorsement of the eminent scientist. It is needless for me to designate the man, as there is but one name so prominent in all the beneficence of all his skilled labors that none can mistake his identity. If, then, the Government of the United States could be prompted to assist in the movement, as they would or could in famine or pestilence, we should soon know *Aletia* only through its simple but exact history, recorded in your Bulletin No. 3.

The method here so urgently recommended is simple, inexpensive, and in no wise prejudicial to health nor endangering life. It is no longer a matter of theory, but a practical test so largely indorsed by public sentiment that none will be found to gainsay its full and faithful promise.

All the planters say, "Give us brilliant and elevated lights with resorbent reservoirs and the earliest flight of the female moth will be attracted to these lights, where it will be sure to meet destruction."

My views, thus presented, are largely influenced by the certain hypothesis that the moths remain in the extreme Southern cotton belt during the winter, and that the chrysalids do not seek an underground hibernation, and hence the main impediment to this mode of warfare is removed. But should a few of the breeders escape the traps set to catch them there will be less difficulty in reaching them with the poisons. If the aid suggested could only be made a free offering to the poor, the more independent class of planters would supply themselves and would willingly aid in the work of destruction. Cotton-planting can never be made a thorough success till this natural enemy of the plant is entirely subdued or rendered less aggressive by thinning out its numbers in some more effective and less expensive manner than is effected by the poisonous compounds.

Respectfully submitted,

WILLIAM J. JONES.

Prof. C. V. RILEY.

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APPENDIX VII.

REPORTS OF CONSULS AND CONSULAR AGENTS ON THE COTTON CROP AND ITS ENEMIES IN MEXICO, CENTRAL AND SOUTH AMERICA, AND THE WEST INDIES.

[In pursuing the study of the insects affecting the cotton plant, as ordered by Congress, and especially of the Cotton Worm (*Aletia xylina*), we found that it was absolutely necessary, for the solution of some of the more important questions, to get a better knowledge than we had been able to acquire of cotton culture and the working of this insect in Central and South America, as also in the West Indies and other foreign countries. It occurred to us that the United States consuls at various points might give the Commission valuable aid in this part of its work if applied to for information. We therefore prepared the accompanying letter of inquiry, which was officially transmitted through the Secretary of the Interior, in October, 1879, to our consuls at the following points, with the request that they reply through the Department to the best of their ability and at as early a date as possible: Vera Cruz, Tehuantepec, Tampico, Tuxpan, Mazatlan, Manzanillo (Mexico); Merida, Campeachy, Belize (Honduras); Carthagena, Maracaibo, Bogotá (United States of Colombia); Barcelona (Venezuela); Trinidad, Barbadoes, Martinique (West Indies); Parà, Pernambuco and Bahia (Brazil).

CIRCULAR LETTER.

DEAR SIR: The United States Entomological Commission is now making a thorough study of the insects affecting the Cotton plant, and especially of the Cotton Worm in the United States, and desires to get facts and statistics regarding Cotton culture and the insect enemies of the plant in ———.

You are respectfully requested to send to Prof. C. V. Riley, through the Department, such facts as you can obtain on the following points:

1.—To what extent is cotton grown and what are the peculiarities of culture?

2.—What are its worst insect enemies?

3.—Does the Cotton Worm or Cotton Caterpillar (*Anomis xylina*, Say, a green looping worm with white lines and black dots encircled with white) attack it? and if so, give its habits, especially during the winter months.

4.—Has this worm always been in the country, or is it believed to be an importation?

5.—How long has cotton been grown in ——— and does it grow wild?

6.—What is the prevailing direction of the wind during the months of March, April, June, and July?

7.—Transmit, if possible, in alcohol, specimens of the worm most destructive to the plant.

The following replies indicate the extent of the information obtained by the above means:]

DEPARTMENT OF STATE,
Washington, December 18, 1879.

SIR: I have the honor to transmit herewith, for your information, a copy of dispatch No. 114, of date November the 22d, in relation to the culture of cotton, from the vice-consul of the United States at Merida, Mexico.

I have the honor to be, sir, your obedient servant,

WM. M. EVARTS.

The Hon. CARL SCHURZ,
Secretary of the Interior.

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No. 114.] UNITED STATES CONSULATE AT MERIDA,
November 22, 1879.

SIR: I have the honor to acknowledge receipt of your dispatch of October 13, 1879, having received the inclosed copy of the letter from the Chief of the Entomological Commission, addressed to the Honorable the Secretary of the Interior, and in compliance with the contents of said letter, I beg leave to give the following information:

The culture of cotton is very little here; it is cultivated only in the southern part of this city, and in very small quantity. It grows to the extent of 12 feet.

No other insect enemies of the cotton plant are known but its worms, and this worm is exactly as mentioned in the letter, that is, a green worm with white lines and black dots.

This worm is always on the cotton leaf, and there is no doubt that by eating the leaf greatly helps to kill the plant. He does not touch the acorn of the cotton, as he remains always on the leaf. If possible by next opportunity I will send specimens in alcohol.

Cotton has been growing here for more than sixteen years, and grows wild, but is inferior to the plant cultivated.

The prevailing directions of winds during the months of March, April, June, and July, are generally breeze and southeast.

Any more information that I may have about the Cotton Worm and the insect enemy of this plant, I will transmit immediately.*

I am, Sir, your obedient servant,

M. CEBALLOS,
United States Vice-Consul.

Hon. W. HUNTER,
Second Assistant Secretary, Washington, D. C.

No. 22.] UNITED STATES CONSULATE AT TAMPICO,
November 25, 1879.

SIR: I have to acknowledge receipt of your separate dispatch dated October 13, 1879, and inclosing a copy of a letter from the Chief of the Entomological Commission, addressed to the Honorable the Secretary of the Interior, under date of October 6, 1879.

In pursuance of your instructions I answer as follows, and in their respective order to the points as given in the letter aforesaid, to wit:

1. Cotton has never been grown to any extent in this district; however, the several attempts made at its culture have proved agricultural successes. The plant is known to keep four, sometimes five years, producing a first crop, which for its superior quality might be classed middling fair. The successive crops declining in quality and quantity. Two crops can be gathered in eighteen months.

2. Besides the caterpillar, which is said to be larger than that of the United States, the plant here has another very destructive enemy in the large brown emmet, commonly named here *arriera*.

3. The caterpillar invades the cotton fields of this country in about the same manner as in the United States. The worm, if I am correctly informed, is of a dark green color, with jet black eyes; is larger than ours and with no *white lines* nor *black dots*. It generally appears in the dry season.

4. The worm is not believed to be imported, it being known to exist in this country ever since the cotton plant was discovered.

5. The plant was found growing wild by the Spanish conquerors.

6. The wind generally prevails in the easterly direction (sea breeze) all the year round in this district. In the winter months it is occasionally visited by strong northers.

7. I have already written for a specimen of the worm, which will be forwarded as soon as practicable.*

I am, sir, your obedient servant,

AUGUSTUS J. CASSARD,
United States Consul.

Hon. W. HUNTER,
Second Assistant Secretary of State, Washington, D. C.

No. 41.] UNITED STATES CONSULATE, MARTINIQUE, W. I.,
December 11, 1879.

SIR: I have received your communication of October 13, 1879, inclosing a copy of a letter from the Chief of the Entomological Commission seeking information relating to the cotton plant.

In reply, I respectfully beg leave to inform the Department that I have made in-

* No specimens received.—C. V. R.

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quiries in various directions with the following result, viz: Cotton is not cultivated to any extent in Martinique. There is not a cotton plantation upon the island; there are only a few trees here and there, and these grow wild upon the southern part of the island. Its worst insect enemy is a green-looking worm with white points on either side. I am told that this worm has been here since the first cultivation of cotton upon the island. The prevailing direction of the wind during the months of March, April, June, and July, is east-northeast.

I am sir, very respectfully, your obedient servant,

W. H. GARFIELD,
United States Consul.

To the Honorable ASSISTANT SECRETARY OF STATE,
Washington, D. C.

CONSULATE OF THE UNITED STATES OF AMERICA,
Trinidad, B. W. I., December 20, 1879.

SIR: I have the honor to acknowledge the receipt of your circular of October 6th, on the 11th instant, and in reply would state that I have made inquiries of the Govment botanist, and am informed that cotton is not cultivated on this island, and that the worm mentioned is unknown here.

The prevailing wind during the months of March, April, June, July is from the east.

I am, sir, your obedient servant,

FULTON PAUL,
United States Consul.

Hon. CARL SCHURZ,
Secretary of the Interior, Washington, D. C.

No. 96.] UNITED STATES CONSULATE AT MANZANILLO, MEXICO,
December 26, 1879.

SIR: In compliance with instructions contained in your communication dated November 26, including letter of inquiry from the United States Entomological Commission, transmitted through circular of the Department of the Interior, under date of October 6, I now have the honor to submit the following report upon the culture of cotton in this state, and also upon the insect enemies affecting this plant:

1. The tracts of land suitable to the culture of cotton in the vicinity of this port, and pertaining to the dependencies of this consulate, embrace from 25,000 to 30,000 acres, of which from 6,000 to 7,000 acres are actually cultivated with cotton.

The time for planting commences about the 1st of October, just after the severe storms of the rainy season have passed.

The plant begins to blossom about the middle of December, and high lands are ready to be harvested about the 15th of April. The picking season lasts from one and a half to two months.

The culture is conducted in the most primitive way. Plows are not used. The land is never manured, there being no need of it.

A piece of land is cleared off; the timber and brush burned, and corn planted. About the 1st of October the rows between the corn are cleared and the planting of cotton commences.

The seed is soaked for two or three hours in water, and planted with the aid of an instrument similar to our hoe, termed here "tarecua." As soon as grass comes up between the rows it is chopped down with this same instrument, a work which has to be performed three or four times on old lands and but once on new lands.

The greater portion of land under cultivation is new, perfect virgin soil, the proportion being one-fourth old and three-fourths new lands. After a field yields three fair crops it is generally abandoned and new lands cleared off.

In favorable seasons (warm, sunny weather) from 18,000 to 20,000 quintals clean lint are raised. In bad seasons the total crop here averages from 4,000 to 5,000 quintals. The average yield of an acre is 1,000 pounds cotton in seed; yet favorable spots have yielded as much as 2,500 pounds in seed to the acre.

2. A small white worm destroying the young fruit or cotton boll is considered here the most injurious insect. It enters the boll when quite small, the mark left where it made its entrance being hardly perceptible, not larger than the point of a pin. The worm grows with the boll, eats the inside pulp, and causes the boll to drop off. Frequently the worm cannot devour the whole contents of the boll, and in this case only one or two sections are destroyed, and the boll matures.

It seems that the development of this boll worm is greatly influenced by the weather. I have observed that during cloudy and moist weather in January and February the boll worm abounds on old lands, causing great damage, whilst abundant sunshine

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and clear, dewy nights during those months seem to protect the plantations against the ravages of this insect. The Mexican farmers, aware of this fact, have given the boll worm the name of "Chahuistle," which is an Indian word for cloudy, misty weather.

The damage caused by this worm on new lands is small; also on old lands where the plant has been set wide apart, say from 8 to 9 feet.

I therefore draw from these observations the following conclusions, viz: The larvæ deposited by the moth on the ground remains there from eight to nine months, the young worm appearing just at the time when the cotton plant throws out the bolls.

Plowing and thorough tilling should be a preventive against this worm. Sunny weather destroys it. Setting the plants wide apart, at least 6 feet, would allow the sun to heat the ground, and must be, in my opinion, beneficial.

3. The larger worm, or caterpillar (*Anomis xylina*) has made its appearance on this coast three times during the last twenty years; in 1866, in 1873, and again in 1878. It is a dark-green looping worm, with white and black lines, and destroys the cotton plant by devouring the leaves. It is as yet impossible for me to find out the origin or even habits of this worm. I have investigated the supposed causes of its appearance, but without success; the farmers here have not the slightest idea about it. An apparent coincidence between the appearance of this plague and overflooding of rivers in the cotton regions should be mentioned here.

September, 1865. High floods; complete inundation of cotton lands.

February, 1866. Appearance of the caterpillar in small numbers, not causing much damage.

September, 1872. Floods; partial inundation of cotton lands; high lands and ridges in the valleys not flooded.

February, 1873. Appearance of the plague and total destruction of cotton plantations.

September, 1878. High floods; complete inundation of cotton-growing valleys.

February, 1879. Partial plague; small damage done by the caterpillar.

4. In answer to question 4 I would refer to above statements. I draw from them the opinion that the worm has not been imported into Mexico, but originates in the cotton valleys in such seasons when the peculiar condition of the soil and climate combine to favor the development of larvæ brought down by floods from the mountain lands.

The cotton lands in this vicinity are bounded on the west by the Pacific Ocean, on the east by high mountains, la "Sierra Madre;" on the north and south by dense woods and tracts of uncultivated lands. These circumstances present a great many obstacles to the flight of the cotton moth. The nearest cotton plantations, as well to the northward as to the southward, are at a distance from Manzanillo of at least 100 miles.

Cotton has been grown in the State of Colima for the last fifty years. It does not grow wild, but, if abandoned, some plants grow up to good-sized trees, bearing fruit regularly every year.

6. The directions of prevailing winds on this coast are the following, viz: January, south and west; February, west and northwest; March, west and northwest; April, northwest; May, northwest; June, south and northwest; July, south and west; August, south and west; September, south and west; October, south and west; November, south and west; December, south and west.

The northwest and west winds blow generally during the day; at night these winds change to the north and northeast.

I give the prevailing winds for the whole year, as our planting and picking seasons here are different from those in the United States.

7. It is not possible for me at present to remit specimens of insects that attack the cotton plant, but reserve myself the privilege to do so in February next—the time when these different insects make their appearance here.*

I am, sir, your obedient servant,

AUGUSTUS MORRILL,
United States Consul.

Hon. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

No. 77.] CONSULATE OF THE UNITED STATES,
Masatlan, December 3, 1879.

SIR: I beg to respectfully acknowledge receipt of communication dated October 13, 1879, inclosing a copy of a letter from the Chief of the Entomological Commission addressed to the Honorable the Secretary of the Interior, under date of October 6, 1879,

* No specimens received.—C. V. R.

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in which information touching the production of cotton, and the attack of the Cotton Worm and other insects upon the plant, in Central and South America, is requested for the use of the Commission; and desiring a report on the subject to be sent to the State Department for transmission to the Commission.

I beg to inclose herewith such information as I have been able to secure, and suggesting that the consul at Acapulco may be able to give more particular and valuable information, from the fact that a large amount of the cotton used in the cotton mills of this State comes from his consular district.

1. Cotton is not grown to any considerable extent in this consular district on account of the uncertainty of the crop, as much through rains as through the attacks of insects. The production is not sufficient for the three cotton-mills in operation in this State.

Cotton is planted in August and September, about 4 feet apart, receives but little attention; is gathered during the months from December to May, giving about 40 arrobas (25 pounds) to the acre, and selling at $1.25 to $1.50 the arroba of seed-cotton. Labor costs from 50 to 75 cents per diem.

2. The Cotton Worm, or as known here by the name of the Army Worm, the Bud Worm, and the Boll Worm, are the worst insect enemies.

3. The regular Cotton or Army Worm attacks the cotton plant every year, but about once in four years is very destructive. It appears to be deposited by a fly on the under side of the leaf, which rolls up and in a few days the worm of about 2 inches appears. During the winter months it disappears.

4 and 5. Cotton was first introduced into this State in 1863 by an American, Mr. Francis Nolan; was produced from seed brought from the State of Guerrero. It does not grow wild in this State. The first years but little trouble was experienced from the Cotton Worm, but each year they have given more trouble, especially if cotton is planted again on the same ground.

6. The prevailing direction of the wind during the months from March to July is from the east in the morning, and from the southwest in the afternoon.

7. I have requested specimens of the above-mentioned insects, and will forward to the Department of State as soon as received.*

I have the honor to be, sir, your obedient servant,

E. G. KELTON,
United States Consul.

Hon. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

No. 193.] UNITED STATES CONSULATE,
Bahia, January 12, 1880.

SIR: I have the honor to acknowledge the receipt at this consulate, on the 29th of December ultimo, of dispatch from the Department of State dated October 13, 1879, inclosing a copy of a letter from the Chief of the Entomological Commission to the Hon. Secretary of the Interior, requesting information in regard to the production of cotton in this consular district, and the attack of the Cotton Worm and other insects upon the plant; and in reply have most respectfully to report upon the particular points stated upon which information is requested, as follows:

1. Cotton is not grown at present to any considerable extent in this province, and has ceased to be an article of exportation. The cultivation is simple in the extreme, requiring little care or attention, but owing to the distance from this port of the cotton-producing districts the cultivation has long since ceased to be remunerative.

2. The insect enemies of the cotton plant which particularly attack it consist of two species of moths, which, in the form of worms or caterpillars, prey upon its leaves and stalk, as also the cotton pod itself. It is also attacked by a peculiar species of bug, specimen of which is forwarded, and by the grasshoppers, which commit great ravages upon the foliage and the tender stalk.

3. The Cotton Worm, as described by Professor Riley, is somewhat different from the worm in this province, differing in color and other respects, but it no doubt is in reality of similar character.

The Cotton Worms of this Province are produced by moths laying their eggs in the leaves and young buds of the cotton plant, which become worms and caterpillars and feed upon the cotton until transformed again into moths. The ravage committed by them is greater in the dry or summer months, say September, October, November, and December.

4. The so-called Cotton Worm is believed to have been always in the country and not imported.

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* The specimens were Aletia.—C. V. R.

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5. Cotton has been grown in this part of Brazil for as long a time as any other production, and it is also found growing wild.

6. The prevailing direction of the wind during the months of March, April, June, and July is easterly, varying from northeast to southeast.

7. I transmit herewith separately in a box the following specimens:[62]

(1) Cotton leaves with chrysalis of *Xylina* (*Noctua*).

(2) Larvæ, or caterpillar of the same insect, which changes from a green to a light-red color, formed by different colored lines running crossways, when it attains its full state of maturity. The larger of these worms feeds upon the leaves; the small upon the buds of the cotton plant.

(3) The butterfly of the same larvæ.

(4) Cotton buds destroyed by the moths containing the larvæ and chrysalis, some of which have already been transformed into moths.

(5) Several larvæ of the same and one cotton bug.

(6) Cocoons formed from cotton by the larvæ in the interior of the buds.

(7) Another species which preys upon the cotton seed inside the pod.

(8) A drawing of the worm before its color changes.

I have the honor to be, Sir, with high respect, your obedient servant,

RICH'D A. EDES,
Consul.

Hon. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

No. 40.] UNITED STATES COMMERCIAL AGENCY,
Maracaibo, February 18, 1880.

SIR: In answer to your dispatch of October 13, 1879, requesting particulars about the cultivation of cotton in this country and the prevalence here of worms and other insects which attack the cotton plant, for the information of the Entomological Commission, I beg to state that having given the matter my careful attention, I am now enabled to answer the questions put in the document referred to, in their turn.

1. Cotton has been grown in the State of Zulia, one of the sovereign States of the Republic of Venezuela, and more so in the neighborhood of Maracaibo, some ten or fifteen years ago. It was raised to a large extent in small as well as in large quantities and everybody took to it. Some foreign houses advanced large sums to native growers in order to establish cotton for export. The quality produced was very good and sold well in America (the United States) and in Europe, but the revolutions which broke out caused whole crops to be lost, as they could not get hands enough to gather the cotton in time, and the parties who had invested large sums in its cultivation got discouraged in consequence of the losses incurred and gave it up entirely, and no one has ever made another attempt to raise it again. The general opinion was, and is still now, that it does not pay to raise cotton on a large scale, on account of the scarcity of labor available to gather in the crop in the proper time. This, however, is not the result of a paucity of population, but rather the consequence of a state of things which enables the laborers to live on so little, that the necessity to work continuously, such as it is required for the profitable carrying on of a cotton property, ceases entirely under ordinary circumstances. They would only do so when driven by extreme necessity or induced by such disproportionately high wages as would raise the cost of growing the cotton beyond the possibility of making any profit. The wages referred to in those times were, in addition to the daily rations, which cannot be furnished for less than thirty cents per day for one man, $6.40 per month, making a total disbursement of $15.40 per month for the labor of one man, or about $20 of the money of the country.

As the people of this country are naturally very slow to work, and cannot be induced to take task work, the maximum quantity of cotton picked by one man has been calculated never to exceed 100 pounds per day, which, at the prices for labor before mentioned, is out of all proportion to the price obtained for the cotton, and causes such an undertaking to prove a losing concern. The soil of this district is as favorable to the growth of cotton as the climate, which is rather dry, and there are two crops in the year, one in July and the other in December, the plants producing at both times in abundance. The land itself is of little value and the expenses are only those of cultivation. There were several large haciendas raising cotton in the neighborhood, but they are now lying waste and the machinery is rusting and spoiling.

2. That the worst enemy of the cotton-plant is the caterpillar. There are two distinct kinds. One is green and rather small and the other kind has a green belly and a yellowish back with brown stripes. There is also a kind of ant, which injures the cotton-plant by making its nest under the roots, causing the stem to dry up entirely.

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3. The caterpillars generally appear in spring time, that is to say, in February and March, and at times in such quantites that they succeed in destroying whole plantations of cotton. If, however, the rainy seasons continue a short time beyond their usual period, they are almost all destroyed by the rains.

4. These caterpillars have been known ever since the first time that cotton was raised here, and so far as I can gather from information received, are indigenous to the country and in no way imported from elsewhere.

5. Cotton has been cultivated here for the first time some fifteen years ago. Up to that time it was known to grow wild all over the country, producing a very good quality of cotton and now since the cultivation has been totally abandoned, it continues to grow wild without the least care, without any deterioration in quality, as may be seen from the sample sent. What little cotton is gathered now from the plants growing wild fetches a price of $3.20 per 100 pounds uncleaned, and as it takes about 350 pounds of crude cotton to produce 100 pounds of clean cotton, the price in addition to the cost of cleaning would amount to such a height as to put the possibility of exporting it entirely out of the question.

6. The elevation of the lands on which cotton has been grown here above the level of the sea is from 50 to 100 feet, and the winds that prevail in that part of the country are north-northeast and south-southeast.

7. In compliance with your request I send a bottle with specimens of the caterpillars in question, as well as a bag with samples of crude cotton, gathered in the vicinity of this town, where the plants grow wild, as referred to in the above report.[63]

The samples of cotton and the caterpillars will be forwarded by the first sailing vessel, the Alcira, for New York, which will leave in about ten days, to save expenses.

Hoping that this report may be of some benefit, I have the honor to remain,

Your most obedient servant,

E. H. PLUMACHER,
Commercial Agent.

Hon. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

No. 347.] U. S. CONSULATE,
Vera Cruz, March 3, 1880.

SIR: On the receipt of yours of October 13, concerning cotton culture, and the enemies of the cotton plant, statistical data on which for this district was asked to be given to the Entomological Commission, I immediately translated the seven questions into Spanish, with a circular letter, and sent them to various prominent persons who were recommended to me as men well informed on the subject, under inquiry, asking them to give me the data required at as early a date as possible. Some answered promptly, saying, however, that it was too soon to procure specimens of the worms, but giving no other response. Yesterday I received a bottle with many specimens in diluted alcohol. This bottle I transmit for the use of the Commission, and send also a translation of a letter from Señ. R. de Zayas Enriquez, explanatory of the contents of the bottle. (64) These are the only specimens I have been able to obtain, although I have personally made some excursions into cotton districts for them, and other points of inquiry indicated by the Commission.

QUESTIONS AND ANSWERS.

1. "To what extent is cotton grown, and what are the peculiarities of culture?"

Answer. In this consular district about 8,000,000 pounds are produced. The peculiarities of culture are striking. The ground is prepared by removing rubbish, and then the seed is planted by inserting a sharp stick in the ground at convenient intervals; into the holes thus made the seed is deposited and covered by the foot. No plows are used in this preparation for the seed, nor are they often used in the subsequent stages of cultivation. They pull out the larger weeds or use the hoe, confining their labor to but little more than such. It is clear from that kind of culture that the cotton plant must be forced into much bad company, and be assaulted with destructive enemies. After extensive inquiries I find no one scientifically informed on the full habits of these enemies.

2. "What are the worst insect enemies?"

Answer. The Cotton Worm, grasshopper, and ant. The ground mole in some localities is very destructive.

3. "Does the Cotton Worm (described) attack it? and, if so, give its habits, especially during the winter months.

Answer. Yes. See inclosed translation of a letter from Judge R. de Zayas Enriquez, who has given me the best information he could gather; but the Honorable Commis-

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sion will at once see its imperfections and inaccuracies. It is a hotly-disputed point as to what becomes of the worm during the "six or eight years" when it does not appear, and no one in my circuit of acquaintance gives me anything better than a superstition for a solution of the problem. Our climate never giving us frost, scarcely affects the constant germinal qualities of plants or the enemies thereof; and it has been asserted to me that at one place or another the Cotton Worm can always be found. However, the difficulty I have experienced in obtaining the specimens sent, induces me to doubt the correctness of that assertion.

4. "Has this worm always been in the country, or is it believed to be an importation?"

Answer. It has been here as long as cotton has been cultivated by the Mexicans.

5. "How long has cotton been grown in Mexico, and does it grow wild?"

Answer. We have historical accounts that cotton was grown and utilized since the twelfth century, but have no data that it was or was not naturally indigenous. But if said history be reliable it is fair to presume that it was indigenous, because there is no knowledge of commercial relations with foreign countries at that period. At present, however, there is no evidence of its being indigenous any more than the banana plant or other produce known to be of foreign origin.

6. "What is the prevailing direction of the wind during the months of March, April, June, and July?"

Answer. Easterly and southeasterly.

7. "Transmit, if possible, in alcohol, specimens of the worm most destructive to the plant."

Answer. The specimens I send I transmit in the same condition as received. I was promised the grasshopper and the ant, but the specimens have not been sent to me, and I have been so far behind time with my report that I do not deem it right for me to wait longer for them. They devour the cotton plant in common with every other green substance and are not a specific enemy of it. So, too, of the ground mole.

Your obedient servant,

S. T. TROWBRIDGE,
Consul.

Hon. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

[Enclosure—translated.]

VERA CRUZ, *March* 2, 1880.

DEAR SIR: I send you a bottle containing various kinds of worms that destroy the cotton and plant. They are all I have been able to procure. This is now the part of the year in which the worms usually appear, and have been gathered near San Andres Tuxtla, on the southern coast from here.

I think some of the samples I send you do not attack the plant, but live on it without harming it. The large thick ones of the tobacco color with black half moons are of that species. The narrow green ones having two black lines on the body are, in my opinion, the only ones that attack the cotton plant. You will see other samples of the caterpillar in the state of chrysalis, and other Lepidoptera.[54] On the coast they are called palomas or salomilla (chrysalis or aurelia). Said paloma is ash color, and is nocturnal in its habits; is, in reality, a bombyx, which produces a multitude of microscopic eggs on the plant, which eggs create, in short, the worm, also microscopic, and which commences immediately to devour the plant, and so continues until it gets to the state of enrollment to pass the last metamorphosis.

This worm is in my opinion the *Anomis xylina*, or *Noctua gossypii;* but I may be mistaken.

I have not been able to obtain the data sufficiently clear to say whether they were imported into this country, but I am assured that they do not make their appearance every year at the same place; or, better said, they only come one or two years in succession; then disappear for six or eight years. They are not to be found in all the country at one time. Their reproduction is usually ascribed to our southern coast.

I understand their invasion can be victoriously combatted by sprinkling dry chloride of lime over the ground and plants, or an aqueous solution of the same, and I have recommended this remedy to those living on the coast for a trial.

I hope these data may be of utility, and I improve this occasion to place myself anew at your orders, repeating myself,

Yours from my heart,

R. DE ZAYAS ENRIQUEZ.

Consul TROWBRIDGE.

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No. 42.] UNITED STATES CONSULATE,
Pernambuco, March 20, 1880.

SIR: I have the honor to transmit herewith my report to the Entomological Commission on the cotton culture and the insects affecting it injuriously.

I find it very difficult to get any reliable information on that subject. One correspondent from whom I expected a full account has failed me entirely.

Such as I have I forward, fearing that it will give but very little satisfaction to the Commission.

I am, sir, your obedient servant,

ANDREW CONE,
United States Consul.

HON. WILLIAM HUNTER,
Second Assistant Secretary of State, Washington, D. C.

CONSULATE OF THE UNITED STATES,
Pernambuco, March 18, 1880.

DEAR SIR: Your letter of inquiry in regard to cotton culture and the insects affecting it injuriously, is before me, and I do myself the honor to reply.

You say, "I find that it is absolutely necessary for the solution of some of the more important questions to get a better knowledge than we have so far been able to acquire of cotton culture and the workings of this insect in Central and South America," &c., and you think the consuls at various points therein mentioned might give the Commission valuable aid in this part of its work.

Permit me to ask, with all due deference, whether men in these benighted countries, centuries behind the United States in skill, knowledge, and development, *can* enlighten the scientist at home; nevertheless, I have done what I could and forward the result.

I have tried in vain, through my Brazilian correspondence, so slow in transmission, to inform myself on this as well as other matters relating to Brazil; but it seems nearly as difficult to keep one's self posted in the progress of affairs here as it is to obtain information from the interior of Asia.

I wish it were my luck to discover all about the persecutors of the cotton plant, and the remedy for these pests. I should be only too happy to know how to combat these enemies to the greater prosperity of the United States; to exterminate these devastators, without which I believe the annual cotton crop of our country might be doubled.

There is no particular skill required in the cultivation of cotton in Brazil. The seeds once put into the ground will soon become plants, and then they only require weeding once or twice a year, according to the season; the more rain rendering the more weeding necessary, of course.

The plant in general use in these provinces is the perennial, which grows into a shrub and produces several years. The largest crop is taken the third year, when it deteriorates, and is not worth gathering after the fifth year.

The herbaceous is of a poorer quality, and is only used because it produces quickly. Neither variety is indigenous to the soil of Brazil.

As to the culture of cotton in Pernambuco and the other provinces subject to this consulate, viz., Ceara, Rio Grande do Norte, Parahiba, and Alagoas, no correct estimate can be given of the amount of land or acreage under cultivation. No planter or owner of a fazenda ever knows how many acres of land he possesses or how much land constitutes an acre, but owns what is embraced in certain metes or bounds.

The cultivation of cotton is rapidly decreasing here, the price being too low and the export duties too exorbitant for a profitable business.

The number of bales entered at the port of Pernambuco for the year ending September 30, 1872, was 335,180 bales of about 180 pounds each, while the number of bales entered for the year ending September 30, 1879, was only 30, 168, planters having turned their attention more to the cultivation of sugar-cane, which pays them better.

Most of the districts of the different provinces are adapted to the cultivation of cotton even on the serras, where there is abundance of rain. It will grow on almost any soil, but to the greatest perfection in yellow or red clay, the latter being preferred.

The foes most fatal to the cotton plant are the different kinds of caterpillars, which in some years increase to a frightful extent, destroying entirely the crop, and even the pasturage—the absence of regular rains, and "the blight." The blight is caused by cold nights, or cold rains coming unseasonably in contact with the warm soil, after which the sun burns and scorches up the pods and even the small germs of the plant. With the blight vanishes all the hopes of the planter.

The Cotton Worm or caterpillar, *Anomis xylina*, particularly described in your letter, attacks the plant in these provinces. It appears simultaneously with the other varieties at the beginning of the rainy season and never alone. It comes and disappears with the rain.

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So far as can be ascertained from observation the *Anomis xylina* is believed to be a native of the country. During some entire years it is extremely rare to see a caterpillar whether there be sun or rain, wet or dry weather. Some varieties, however, seem consequent upon the action of the sun, and others upon the action of the rain, appearing and disappearing as if by enchantment.

There is an insect called the "mofo" by the planters because of its gray moldy appearance, but the accounts given are so vague and conflicting that I am unable to determine precisely to what variety it belongs. May it not be the "*Tortrix carpas?*" It is believed to have come from the southern provinces about the end of the first quarter of this century. It is almost always present among the cotton plants, especially in seasons when there is a scarcity of rain.

There is no certain data as to the introduction of cotton into these provinces, but it is thought to be about the beginning of the last quarter of the eighteenth century, when the Marquis de Pombal tried to establish extensively in these and other provinces the cultivation of all colonial plants.

The prevailing direction of the wind is east in March, southeast in April, south in June and July. But during the last three years of drought they have been more from a northerly direction.

So far, I have not been able to get any specimens of the moths or caterpillars.

Regretting the paucity of these facts with which you are doubtless familiar, I have the honor to be, sir, your obedient servant,

ANDREW CONE,
United States Consul.

C. V. RILEY, Esq.,
Chief of the U. S. Entomological Commission, Washington, D. C.

No. 28.] UNITED STATES CONSULATE,
Bogota, April 5, 1880.

SIR: Referring to the communication from the State Department of October 13, 1879, I beg to inclose two original notes received from the Colombian Commissary of National Agriculture concerning the cultivation of the cotton plant, &c., for the use of the Entomological Commission at Washington.

As I receive further reports I shall not fail to remit them.

I have the honor to be, sir, your humble, obedient servant,

BENDIX KOPPEL,
United States Consul.

The Hon. SECRETARY OF STATE,
Washington, D. C.

[United States of Colombia. Office of the National Commissioner of Agriculture. Department of the Treasury and the National Credit.]

BOGOTA, *March* 30, 1880.

SIR: From a report sent to me from Socorro by Mr. Albert S. Nieto, I extract the part relating to cotton, in order to furnish to you data which you have requested on behalf of the Government of the United States of America, for the information of the Entomological Commission of the Department of Agriculture. These data refer to the State of Santander.

Cotton.—About 5,000 hectares of cotton are cultivated, which annually produce, on an average, 2,000,000 kilograms, the value of which, at 12½ cents per kilogram, is $250,000. Eight hundred and seventy-two thousand four hundred kilograms are sent to Boyacá and Cundinamarca. The value of these is $114,050. One million one hundred and twenty-seven thousand six hundred kilograms of this variety are spun in the State, producing 563,800 kilograms of thread, the value of which, at 60 cents per kilogram, is $338,280. This quantity of thread, with the addition of 100,000 kilograms of English thread, costing $242,500, which is at the rate of $1.10 per English pound, is used in manufacturing the following articles: 1,275,000 meters or 25,000 pieces of 51 meters each of common and fine-colored cotton shirting, which is sold at from $12 to $21 per piece, or, say, at an average of $16.50 per piece, making a total of $412,500, and for these were used 300,000 kilograms of thread of both kinds, amounting in value to $350,000; 833,333 meters of linen (lienzo) on which are used 100,000 kilograms of domestic thread, which, being sold at 15 cents per meter, gives the sum of $125,000; 100,000 bed spreads, and in these have been used 250,000 kilograms of domestic, together with a small quantity of English thread.

The remaining 13,800 kilograms of thread are used in making caps and heels for hempen shoes, and in making candle-wicks and other small articles. Twelve pieces of shirting—250 of linen, and 60,000 bedspreads and hammocks, valued at $365,600—are shipped to Venezuela, and to Boyacá and other States of Colombia, and the remain-

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dejis consumed at Santander, where about 200.000 (pieces or meters?) of linen imported from Bogota, and valued at $40,000, are also consumed.

Let these data suffice until I am able to send you those of the other cotton-raising States.

Very respectfully, your obedient servant,

JUAN DE DIOS CARRASQUILLAS.

Mr. BENDIX KOPPEL,
United States Consul at Bogota.

[United States of Colombia. Office of the National Commissioner of Agriculture. Department of the Treasury and the National Credit.]

BOGOTA, *March* 22, 1880.

SIR: Of the data which I have requested in behalf of the Entomological Commission of the Government at Washington upon certain points relating to the cultivation of cotton, I have to-day received the following, which have been furnished to me by Mr. Francisco J. Balmaseda, President of the Central Board of Agriculture of the State of Bolivar, in an official note numbered 511, and dated Cartagena, February 21, 1880.

Mr. Balmaseda says:

Referring to the questions of the Entomological Commission of the Government at Washington, I will answer them in their order.

1. In the State of Bolivar, during the war for secession in North America, cotton was cultivated on quite a large scale, and was sold in Europe as high as 18 pence per kilogram. Its cultivation afterwards declined on account of the cheapness and abundance of American cotton; only small quantities are now exported, and its cultivation is performed by women and boys. From September 1, 1878, to August 30, 1879, the amount exported from the port of Cartagena was but 436 bales, weighing 66,029 kilograms, and valued at $17,525; from that of Baranquilla the amount exported was doubtless greater. The details of its cultivation are as follows: During the months of February and March the laborers clear the ground of trees and brushwood; these they burn at the close of the latter month and plant the cotton as soon as the first showers fall, using the seed, which they place so that there may be an interval of three varas (a vara is a little less than a yard) between each plant; they give it three cleanings, and the crop is gathered from January to March of the year following.

2. There is only a large ant called the "Arriera," which is known in Cuba as the "Vivijagua." Neither the *Anomis xylina* is known nor any insect that injures it (the cotton).

3. There is no Cotton Worm in this country.

4. Whether this worm is indigenous to this country? See answer to question 3.

5. How long has cotton been cultivated in the United States of Colombia, and is it found in a wild state?

It is not found in a wild state, but it is an indigenous plant; the Spaniards found it cultivated by the Indians. There are two kinds of cotton on this Atlantic coast, one called the "riñon," which has a great abundance of seeds and but little wool, while the other, which is the one commonly cultivated, has no particular name.

In the interior of the Republic there are four kinds, known as the "lengupa," "guane," "riñon," and "pajarito." The plant of the kind last named lasts for three years. It is proper for me to say that the cotton plant in this State of Bolivia lives for ten or twelve years, and such is the exuberance of its vegetation that in some localities—and this is a common thing—it attains so great a height as properly to be considered a tree.

Cultivators begin to prune during the second season. The main object of this operation is to prevent the stem from taking a vertical direction and to promote the growth of lateral branches, as the work of picking the cotton is thus rendered easier. It is a curious fact that the natives of what is now the capital of the Republic not only manufactured valuable cotton cloths, but that they dyed them of various colors. So rich were they that on the arrival of the Spaniards during that period of religious fanaticism, these cloths served to cover the ornaments that were used on the occasion when the first mass was said at Bogota.

I trust that these data will be found satisfactory, and that they will be of some service to the Government of the United States. I hope soon to be able to furnish similar information from other parts of the Republic, as I have requested the various State governments and also private persons to procure such and transmit it to the agricultural office under my charge.

I am, sir, very respectfully, your obedient servant,

JUAN DE DIOS CARRASQUILLAS.

Hon. BENDIX KOPPEL,
United States Consul at Bogota.

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NOTES ON INSECTS INJURIOUS TO THE COTTON PLANT IN THE REPUBLIC OF MEXICO.

As the principal cotton planting districts are at some distance from this capital, I have not been able to obtain the specimens of insects requested by the Chief of the Entomological Commission, nor can I flatter myself that the descriptive information which I have been enabled to collect after much difficulty and delay, will be found to be of much practical value. I nevertheless present it for what it may be worth.

1. The most usual and fatal enemy of the plant is a small white worm from 1 to 2 centimeters in length, and in form somewhat resembling a centipede without the feet. When in motion this worm shows streaks of light green. It is believed to be inherent to the plant, always accompanying it, even in the seasons of the most abundant crops. It is usually observed when the plant has attained its full growth and just before it blossoms. This worm attacks the leaf alone, and devours it completely. In bad seasons it is so abundant that in two days a whole plantation will be entirely stripped of its leaves, showing nothing but the bare stalks.

Various experiments have been tried to counteract and destroy this enemy, but none seem to have been attended with good results except the fumigation with sulphur, which has been tried on a limited scale, and has been only partially successful.

2. Another worm somewhat similar in form, but smaller, and of a green color with white stripes, makes its appearance at times, but never in such vast armies, and is consequently not so much dreaded as the former.

3. The third insect mentioned is a large bug of a brown color called the "conchuela," which is never so abundant as the Cotton Worm, but inserts itself into the bud and prevents the maturing of the blossom, thereby causing considerable damage.

4. The "chahuistle" is an insect so microscopic in size that it first appears as a dry, reddish powder covering the leaves and stock of the plant. As it accumulates the mass seems to distil a gummy substance which speedily destroys every vestige of the growth. The chahuistle is common throughout the country, and attacks not only the cotton plant, but other vegetables and cereals, such as beans (frijoles), wheat, and maize.

5. In Durango the crops are reported to suffer seriously from "pocks" (viruela), and in some seasons are severely damaged by locusts.

Ever since cotton has been cultivated in Mexico by Europeans or their descendants it has been more or less infested with the above-described insects, which, however, are not supposed to be indigenous, but to have been imported with foreign seed. Whether this opinion is merely conjectural or founded on well authenticated traditions, I do not know. Hernando Cortez, on landing, found the natives of the country clothed in cotton garments of their own manufacture, but to the best of my knowledge neither history nor tradition has preserved us any information in regard to the enemies of the cotton crop before the coming of the Spaniards.

In the districts near the Pacific coast, after the before-described insects an eclipse of the moon is believed to be the most damaging enemy of the cotton plant. When the eclipse takes place at the time when the plant is in blossom it perishes immediately and completely. The only means of saving any part of a crop under these circumstances is to fumigate with a certain wood found on that coast, which burns slowly and gives out volumes of smoke. The Indians on such occasions imagine they can save their cotton by fixing streamers of red or other gay colored rags upon reeds and sticking them over their fields. The planters of European stock, however, regard this practice as a superstition.

The information here furnished has been derived principally from planters in the vicinity of Tepec and Durango, no reports having been received from other quarters.

DAVID H. STROTHER,
United States Consul-General, City of Mexico.

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APPENDIX VIII.

ANSWERS TO CIRCULAR NO. 7.*

SAINT FRANCISVILLE, WEST FELICIANA PARISH, LOUISIANA,
October 2, 1879.

A circular from you requesting answers to certain questions relative to the Cotton Worm was received some months since, and my reply has been deferred to this date in order to enable me to observe the worm and its depredations throughout the entire season. Last year a similar circular was received from the office of the Agricultural Department, to which I replied fully and specially to all the questions as far as my information extended.

1. Cotton has been grown here since this century began—eighty years—and perhaps longer. I am a native, fifty-eight years old, and my family and relatives came here from North Carolina in Spanish times and soon afterwards, *i. e.*, from 1800 to 1810. They always raised cotton from their first settlement here.

2. I have no records or histories to refer to in order to answer this question fully and accurately. From old settlers I have heard that the Army Worm came here before my recollection—this is, before 1827 or 1828—and destroyed the crops. I think this was between 1820 and 1824. I have heard old settlers who came here from South Carolina say that the Cotton Worm came there before 1815, and ravaged the crops. From my recollection, the worms never appeared here in any great numbers after 1828 until 1840 or 1841. I was raised on a plantation, where I now live, my father and all of my family on my father's and mother's side being large cotton planters, and my recollection dates back to 1828 about all matters of any great moment.

In the above year, 1840 or 1841, I returned home on a visit from school late in the fall, say October, and found the cotton fields white with the open cotton and filled also with Cotton Worms. In a few days they ate all the leaves from the stalks of cotton, and then began to crawl off, moving like a great army, and filling the ruts and washes in the roads and fields with millions of worms, which being unable to crawl out died there in masses. As the worms appeared that year quite late in the season, no damage was done to the cotton crop, except to make the open cotton dirty and trashy from the excrements and cut leaves dropped by the worms on the cotton.

In 1846 the worms appeared again, and that year the crops were greatly injured, the worms eating the cotton up so early in the season that not more than 50 to 70 per cent. of a full crop was made by planters in this section. The worms never came again in sufficient numbers to attract any general notice until after the war began. We heard of their appearance soon after the Federal occupation of New Orleans and the lower part of the State, from the great desire to get cotton to supply the markets and factories abroad and at the North and the many attempts made in that region to raise cotton for that purpose. Inside of the Confederate lines, in this section, very little cotton was raised during the war, the people turning their attention almost exclusively to raising food crops. Worms appeared, however, in the small fields of cotton raised here for several years before the war ended. Beginning with 1866, they have been in this section every year since, sometimes many and again very few; but no year has passed with an *entire* absence of the worm since 1866.

3. I do not think the coldness or mildness of the winters affects the worms here—our winters are never very cold—as our latitude is too far South to permit it. We have had very cold weather, for this section, many times since 1866, and the worms have appeared every year, more or less.

4. They are always worse in wet summers; never very bad in very hot, dry summers. They are generally noticed first in July, and if its after progress is attended by repeated rains during July, August, and September, the crops are very apt to be much injured, if not completely demolished. But if it remains hot and dry during the above-named months, the worms never do much damage.

* This circular is printed in the Introduction.

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5. Of my own knowledge, they are to be seen here first in June or July, but some of my friends and neighbors have reported seeing them occasionally in May, in few numbers.

6. They are almost always found first on the same places and same plantations, scattered over the country, without any apparent regard to character of soil or surrounding circumstances. This fact has been generally noticed and spoken of, but no solution has been made of it that is satisfactory and reasonable. Like most other questions among men, outside of mathematics, discussion never satisfies all parties nor settles the question.

7. I have no experience at all of the winter habits of the insect, but I am satisfied it remains here during the winter, in some form, and does not come here regularly or at intervals from any distance. My reasons for thinking so are too numerous to attempt to write them to you, unless I thought I could prove the fact to a demonstration, and thus settle the matter beyond all future question or dispute.

8. Birds of many kinds prey upon the worms, and many insects prey on both the worm at all ages and stages of its growth and also feed on or destroy the eggs. No quadrupeds disturb either eggs or worms, to my knowledge. Ants of various sorts prey on them—both eggs and small worms. I have heard many insects spoken of, by persons who had given the matter close attention, as being enemies to the Cotton Worms, and preying on or destroying the eggs, young worms, and also those fully grown. I cannot speak on these points from personal knowledge, not being a scientist nor professional man, and having no turn of thought in that direction. I am satisfied that many animals and insects prey on and destroy the Cotton Worm's eggs, young and grown worms, or they would eat up the cotton every year they appear here. They increase by nature so very rapidly after their first appearance that, unless they met many and destructive enemies besides man, they would always increase in numbers so great as to destroy the crop annually. In wet years these various enemies are not present themselves in sufficient numbers to make any impression on the Cotton Worm, but in dry seasons they are numerous enough to nearly annihilate the Cotton Worm, and thus prevent any great damage to the cotton crop.

9. I have no experience about destroying the Cotton Moth. Many might, no doubt, be destroyed by lamps, fires, &c., but the whole planting population would have to engage in it systematically and persistently, or it would amount to nothing. The destruction of any number of moths by a few planters or neighborhoods would do no good. I have never heard of sugar, molasses, or anything of the sort being tried to lure the moths. I think all such things humbugs, and on a par with the Yankee plan tried in Lower Louisiana during the war, *i. e.*, to spread tar around the cotton-fields to prevent the Cotton Worms from entering them.

10. I have no experience to enable me to reply to this question.

11. I cannot afford any information on this question.

12. I have never seen jute nor any other plant being tried in this section for any such purpose. Have heard stories told of such things being tried elsewhere.

13. Paris green, Texas Worm Destroyer, and such poisonous medicines are the only things which have ever been used here to destroy the worms. I have seen Paris green tried many times, and heard of its trial for years. There is no doubt that it will destroy the Cotton Worm and preserve the cotton plants when the preparation is genuine and not a cheat and it is used properly and thoroughly. Like everything else done in this world, it must be done properly, thoroughly, and persistently to succeed. I have no personal knowledge of the Texas Worm Destroyer, but it is very highly recommended, indeed.

14. I have never known any injury to happen to man, beast, or plant here from using Paris green. All know that it is a violent poison, and use it with caution. No doubt, man, animals, and plants can be injured by it, and perhaps all have been injured in some places by its incautious use.

15. Paris green used in liquid form, from large tin watering-pots made specially for the purpose, has been most successful here; it is the preparation generally used.

16. I cannot state the cost of using Paris green per acre, but its cost is not great, and does not enter into any man's calculation when he sets about to kill the Army Worm. I have seen a field of cotton saved by two applications of it, which were made at intervals of a month apart. This field yielded one bale per acre, whereas without the destruction of the worms it would not have made half a bale per acre. These worm poisons are now made and sold in great quantities by responsible parties, and, like all other articles of general commerce, are abundant and cheap. There is no question but that the cotton crop can be saved in part, if not in whole, from any future destruction by the Cotton Worms, in all sections where the planters are energetic, intelligent, and harmonious in action by the use of poisons—Paris green, Texas Worm Killer, arsenic in some form, or some other poison. I cannot now say that any plan can be proposed to destroy the worm or moth before its appearance in the cotton fields. Fires, lamps, &c., would kill immense numbers of moths, but would only retain the worms, and not destroy them.

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I hope what I have written above may prove acceptable to you. I have given you all the information I could which I could vouch for personally. Any future communication from you or your office will be replied to fully and candidly.

The Cotton Worms have made their annual appearance in our parish this year, but have done no general damage. Some few fields have suffered, on alluvial lands, so far as I have heard. The summer has been very hot and dry.

Very respectfully, your obedient servant,

DOUGLAS M. HAMILTON.

C. V. RILEY, *Chief U. S. E. C.*

EVERGREEN, ALA., *August* 24, 1879.

I beg leave respectfully to submit the following answers to your circular (No. 7) concerning the Cotton Worm:

1. About the year 1817.
2. In 1825, or about eight years.
3. It is most generally dreaded after a mild winter, but experience teaches that this fear is ill founded. It is probable that a greater number of the chrysalids survive a mild winter than a severe one, but the present season proves that they cannot all be destroyed by cold, for having passed through the severest winter since their advent, the worms are at this time (August 24) destroying the cotton in some localities, and bid fair to make a clean sweep within the next two or three weeks.
4. Wet springs and summers are decidedly more favorable to their production than dry ones.
5. On or about the 25th of May, 1873.
6. In moist, rich soils, where the weed is most luxuriant.
7. I know but little from actual observation. I have seen the chrysalids in the ground exposed by plowing, sometimes under turfs or logs, or anything that affords protection from cold and wet.
8. None. Every variety of birds feed upon them, but there are not enough birds in a State to devour all the worms on a single plantation. The English sparrow is the only bird that could be introduced which would be available, and it is not considered practicable to try him, for the number required to do the work would require a vast amount of food at all times, and of itself become a greater pest to the farmer than the worm.
9. All efforts in this direction have been fruitless. The writer is of the opinion that as soon as the moth emerges from the chrysalis it proceeds at once to deposit its eggs (of which it contains a vast number), and is not attracted by anything to be eaten until it has performed that function. They are attracted by any saccharine substance, like sugar and water or molasses and water, but, for the reasons stated above, they are considered of little value. Fires or lights will also attract them, and, if not too expensive, might be more available than poisons. Owing to the uncertainty of the time of their advent, and of the very short time required for the laying of their eggs, the plan of destroying by fires can hardly be made available, however.
10. It is immaterial whether the poison is contained in vessels or spread upon boards, trees, &c.; they are as likely to find it at one place as another. The writer has seen myriads of them destroyed by dropping into evaporators used in making sirup. This, however, is never observed until late in the fall, after the cotton is destroyed and the color of the moth is changed. The last crop of worms are black, or nearly so, and the moth springing from them is of a darker hue than the first seen, and is non-productive. Those coming from the green worm are brown, and supply all the eggs.
11. There are none known to the writer.
12. I have no experience with jute, but have seen cotton grown among corn escape the ravages of the worm when all other was destroyed. The writer does not favor the plan, however, practiced by many cotton planters, of crossing cotton with corn at from 12 to 20 feet, inasmuch as the effect of retarding the progress of the worm is not successfully attained, and the corn thus made will little more than pay for the cotton lost, besides impeding the cultivation of the cotton in case the corn is blown down or bent by wind (as happens as often as not). In the opinion of the writer, the better plan is to plant *cotton in corn; i. e.*, after securing a stand of corn early in the spring, plant a hill of cotton between each two hills of corn, so what corn is made may be considered clear gain. If the corn is not bent, the cotton may be worked after the corn is "laid by," and if it is bent, so as to prevent the cultivation of the cotton, nothing is lost by having the cotton there. Of course this plan can only be made profitable on good land, where the cotton will continue to grow after the fodder is pulled. The writer saw last year, however, on poor land, more than 200 pounds of cotton per acre gathered from land where 15 bushels of corn were grown, and this with one additional working. Moreover, cotton grown alone immediately by the side of this corn and cotton was entirely destroyed by worms, *while that grown with the corn was untouched.*

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13. Nothing. From experience in the use of a tea or decoction of the China berry on cabbage, to drive away worms, bugs, &c., the writer is induced to believe that the same might be used with success on cotton. It is well known that all insects or vermin are averse to the taste or proximity to this plant, and the writer has no doubt that a thorough application of it to cotton, made at the proper time, would drive off the worms. I will not undertake to say that it is practicable, for the labor of making the tea and applying it may overbalance the profit. In other respects, however, it has the advantage of being cheap and harmless.

14. I have seen the cotton plant scorched and ruined by using the poisons in too concentrated a form, but have seen no injury to persons or animals. Being a deadly poison, however, the Paris green will certainly kill animals as well as worms if taken into the stomach. It acts as a poison also when introduced into the system through the blood, and should consequently be handled with a great deal of care.

15. Of the means yet discovered, no agent has the advantage of Paris green.

16. For the protection of cotton of average size of weed, an outlay of about $2 or $2.25 per acre will be incurred in this locality, including the cost of the poison, flour or gypsum for mixing, and labor of applying. In places where water can be had without too much labor the cost might be a little less; but comparatively few farmers have this natural advantage.

The writer takes occasion, in this connection, to suggest a solution of the "caterpillar question" in a very few words. Let every cotton planter in the South adopt a system of reduced acreage, high manuring, and thorough cultivation. Let him plant only such lands as will return a large yield, say one, two, or three bales per acre, and he can afford to apply Paris green and save his cotton. Of course, this can be done in most sections of the South only by high manuring; but no farmer should plant more cotton than he can make remunerative. If he can manure but one acre, let him plant but one. This system would not only save the cotton from destruction by worms, but would immeasurably improve the financial condition of the South and the whole country. The farmer, having less cotton planted, would have more land to devote to grain-crops and stock-raising, and after one or two years the market value of cotton would be so enhanced that he would receive as much money for his few bales as he now does for his many.

Very respectfully,

ROBT. A. LEE.

C. V. RILEY, *Chief U. S. E. C.*

HENDERSON, TEX., *November 27*, 1878.

In reference to our Cotton Caterpillar, it is hard to drive to an uncontested conclusion, as there are almost as many opinions as there are cotton farmers in the South.

I am a native of Louisiana, sixty-four years old, and have been growing cotton the greater portion of my life; still I know but little that is worth telling in reference to this terrible Southern pest. The first Cotton Caterpillar I ever saw was in Holmes County, Mississippi, in 1846. The second time I saw them, in numbers worthy of notice, was during our last unfortunate war, 1864. Since then they have appeared annually (more or less) in all the Cotton States. *They appear to be migratory*, but many deny this, and support their views with some plausibility. But we are taught by experience that they do not appear simultaneously over the whole country, but annually appear in the extreme southern portions of Alabama, Florida, Louisiana, and Texas. We often hear of them four to six weeks before they raise, hatch, and accumulate sufficient numbers to reach the northern portions of these States. The first-comer (or parent) is a small yellowish fly, resembling somewhat our usual summer-evening candle fly. Whether from instinct or not, I cannot tell—but I will call it instinct—the first fly visitors always deposit their eggs in the center of each field. Why so in every instance, if it is not to place himself, as well as his first brood, as far away from birds and other enemies which might annoy them near to the forest trees and woods?

Again, they invariably deposit the eggs in the top—yes, in the bud—of each stalk or plant, for there the little embryo leaf is full of downy fuzz, in which the eggs lie closely bedded, elevated high to the dew, and warm sun, and soon hatch. Now we have the worm, so small as to be almost unobservable, but safely secured in his downy bed, which down is his food for a day or two, when he begins to feed on the yet small and tender leaf, and eats day and night until he webs up, to reappear another fly. This is our first crop; and from first observation of the fly until the second crop appears is about fifteen to twenty days. This second crop proceed as the first, depositing their eggs in the bud, and this time extend their dominions to three-fourths and sometimes over the whole field, maturing as before, giving the third crop, which soon finishes the last leaf of the young fruit. I will add that many suppose this last crop, after devouring the crop, deposit their eggs in old hollow trees, old dry fence-rails, dry weeds, or other dry rubbish, to slumber till another year, and then reappear. This

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does not look reasonable as compared with the observations as above stated; besides, they would then hatch out and reappear at every place where they existed the year previous; so I rather believe they are migratory, and come from the south annually. I am of the opinion that if planters would top their cotton, say, three or four inches below the bud, about the time they see the first fly, much benefit would be had. First, the natural place for depositing the eggs would be removed; second, if any eggs had been deposited about the time of topping, the topped part would become dry in a few hours and the egg would perish; or, if hatched, the little baby worm could not feed on the dry, parched leaf, and would thus perish. If, however, he had strength to make his way to a neighboring stalk, he could not feed so young on the lower tough leaves, as he can only survive on the downy part in the bud first, and then on the youngest and tenderest leaves. Thus he acquires size and strength in a few days to feed on older leaves.

It is natural that they do not deposit the egg anywhere on logs, trees, or woody substances, or even on grown tough leaves, where the diminutive baby worm cannot feed, thrive, and live; so the last or third crop, if deposited on these substances, would soon become extinct. Therefore they are migratory and come from the south.

Then, as a remedy, I would suggest, first, to work and cultivate fast, get a good growth as early as possible, but, large or small, top the cotton as soon as you see the first fly; second, I would urge, as an additional remedy, to put up poles with martin-boxes on the top, and cultivate and raise our black-martin bird. It is a South American bird, innocent and harmless to all vegetation. They arrive here in May, raise their young, and migrate the 1st of September. They are a fine, greedy insect-scavenger, and increase rapidly. Again, they are by nature adapted to the work, because the caterpillar-fly works from about 5 o'clock p. m. till dark each day, and while all other birds retire to roost early, the black martin feeds till dark. In fact, this mode of furnishing artificial homes for birds would invite many of our native birds to occupy these homes, and particularly our bluebirds, which are also fine insect-destroyers. Thus, by largely increasing our birds which feed on these insects, we would be well fortified against the boll-worm fly, which much resembles the caterpillar-fly, both of which appear about the same time, first in small force, and increase very rapidly.

If birds could be distributed over the fields in these artificial homes, they would effectually destroy them on their first arrival, when so few in number. You are aware that in the early history of the Southern States, where the farms were small and few in number, then the forests were vocal with the song of birds. As the fields increased in size the forest decreased, and since our late war the freedmen all, young and old, used every means to procure guns for the purpose of killing game, and no bird, however small and innocent, is allowed to escape their deadly aim. Nor will I stop in condemning the negroes for this unwise practice, but the same holds true of our idle young white men, many of whom indulge in the practice as mere sport. Our forest songsters are now seldom to be seen, their songs are hushed, and the moaning noise of the wind in the tree-top is undisturbed by the note of the bird. Laws should be passed by all the States to put a stop to this unwise practice.

Yours, truly,

JNO. M. WOLKOM.

C. V. RILEY, *Chief U. S. E. C.*

HEMPSTEAD, WALLER COUNTY, TEXAS.

I herewith send replies given by different farmers in this county in answer to the question asked on the first page, and you will see that there is a variety of ideas as to the manner of hibernation.

The questions in Circular No. 7 having been carefully answered, to your first circular, I do not think I can add any more information, save perhaps to reiterate my firmer belief in what I had stated, to wit:

That the worm has four changes: from chrysalis to moth; moth to egg; egg to worm; worm to chrysalis.

That the moth is short-lived, from five to seven days; is not an eater; always an egg-layer; remarkably timid; a strong light readily attracts them; they perform their mission and then die.

That the egg hatches in from about five to seven days; is deposited on the under side of cotton leaf in regular layers.

That the worms as they hatch proceed at once to do their mission, and take from seven to nine days to perfect themselves, when they begin to spin their web. In about thirty-six hours the chrysalis—the hibernator—is ready for its long or short sleep, according to the protection or exposure, the heat or cold, surrounding it. It is the *seed*, that chance may throw on stony ground and it will perish, or it may fall in some sheltered spot and there be preserved through any winter. The cause of so few appearing in spring may, and I think does, result from the fact that so few chrysalids fall into nooks or places suitable to protect them through the winter, and are destroyed by winter's cold or their own decay.

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I suggested that perhaps the plant on which the egg was deposited might give direction or impress the worm with desire to eat of that plant. I am ready to change or modify my views, and say that now I think the plant on which the worm feeds must have the effect to determine the plant for the future worm.

I have observed this year that the Cotton Worms, after finishing the cotton, attacked the crab-grass, and have eaten it up—nothing left in the corn field for stock to eat; looks like a frost had killed it. These worms *did not retain* their *cotton-leaf* color, but underwent a great change; the black streaks were obliterated and green color took its place; the half-grown worms became stouter and shorter and more sluggish and of a dirty green color.

The change in the worm is so great that the identity of the worm has been most stoutly denied by very good farmers, who have said, "if you examine them closely you will find them to be the genuine 'grass' worm." If all things work according to my views, we shall be visited by "grass" worms next spring, which will eventually attack the cotton.

9. A large and strong light carried slowly through the fields will surely destroy the moth; but this must be kept up once a week, and the moth must be startled from its rest.

13, 14, 15. Paris green cheapest, used in powder; if too strong, will kill plant and any animal that will eat the plant. Should be used only sufficiently strong to kill worm and not damage the plant. Animals should not be allowed in fields where Paris green is used.

In regard to the answers herein given, my aim was to get the farmers' individual opinion unbiased, and after taking it down would read it, and ask if I had expressed him correctly.

P. S. CLARKE.

C. V. RILEY, *Chief U. S. E. C.*

Question addressed to farmers of Waller County, Texas.—What is your opinion as to the manner or mode of perpetuation or preservation of the Army or Cotton Worm from one year or season to another? In what condition does it hibernate?

Answer by J. A. PEEBLES.—The miller, or fly, makes its deposit of "eggs" in the fall in the ground; they hatch out in the summer, these eggs reproducing the miller. The miller subsists on some kind of food. Believes in a male and female fly and copulation.

Answer by Dr. J. J. PERRY.—Believes it is propagated in the chrysalis from the chrysalis burrowing in the ground, there remaining intact till the period of incubation has expired, when the moth appears. Duration of incubation from six to nine months. Thorough system of winter plowing would eradicate them.

Answer by JOHN PEEBLES.—Believes the eggs are deposited in the ground by the fly; there remaining till cold weather is over, when they hatch as a fly. They (the fly) subsist on some kind of food while existing; they copulate.

Answer by A. T. BEDELL.—Some of the eggs remain unhurt by the winter and are hatched out in the spring, and in this manner are perpetuated.

Answer by Dr. L. W. GROCE.—Believes the eggs are deposited under the bark of the cotton-stalk, under and at the ground, and in this manner lie dormant through the winter and hatch out in the spring. No copulation.

Answer by J. C. RALSTON.—The fly deposits its egg, which becomes a worm, which becomes a chrysalis, which becomes a fly, which again deposits eggs. The fly does not eat. The egg is the medium of perpetuation, which holds through the winter in a capsule.

Answer by Dr. WILLIAM CLINTON.—The flies, or moths, are brought from the perpetual cotton fields of South America by strong southern breeze. Each year terminates them, and again are brought by southern breeze.

Answer by FRANK COOKE.—Originated in Southern States, is a hybrid or cross from common grass-worm; deposit their eggs on cotton-stalks or in the ground, from which comes the first crop, these eggs lying in the ground till spring. Can be destroyed by deep plowing or freeze.

Answer by Dr. R. C. WATSON.—The moth deposits eggs on leaf, hatches in worm, then goes into chrysalis; depends on peculiar conditions how long it remains in this state, from which comes a moth. The chrysalis hibernates, the fly copulates.

Answer by R. G. WHITE.—The chrysalis drops from the stalk and becomes covered under ground; in this manner is preserved during the winter. The moth copulates.

Answer by B. F. ELLIOTT.—Believes the caterpillar goes in the ground in the fall; then becomes a chrysalis; remains dormant till next summer, when it hatches out a fly. The fly eats, copulates, lives three or four weeks.

Answer by ZACK WOOLEY.—The moth deposits eggs in the fall, which are preserved through the winter and hatch out a worm in the spring, which attacks vegetation; then go to work, web up, and turn to the miller again, which deposits eggs; these eggs hatch out the worm, which goes to work on the cotton. The fly eats, copulates, lives three or four weeks.

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Answer by M. G. STANLEY.—The caterpillar itself deposits eggs in the ground in the fall. This egg becomes the miller. The fly copulates; does not eat.

Answer by W. W. MOORE.—The worm passes into chrysalis and in this condition remains till spring, when it emerges a butterfly. No copulation; no eating.

Answer by A. A. PETTUCK.—The worm goes into the ground; there changes to chrysalis and remains till spring, when the butterfly comes forth to deposit eggs to start the worm; fly copulates and eats.

Answer by W. J. BUCHANAN.—They go into the stalks of cotton or small stumps at or near the ground; there they stay as a worm until we see them as a fly in the spring. The fly copulates; lives upon juices of flowers.

Answer by WILLIAM AHRENBECK.—They pass into the ground in the chrysalis state; there remain during winter, become perfected by spring, and come out a fly in spring; must be male and female; do not eat.

Answer by DANIEL LOGGINS.—They go into the chrysalis and remain in that condition till next year, when they come out a butterfly; copulate; do not eat; fly lives four days.

Answer by Dr. R. H. BOXLEY.—They pass into chrysalis state, and in this manner hibernate, when they emerge the next year a fly. The fly copulates, but does not eat; lives three days.

Answer by N. K. ALSTONE.—The caterpillar deposits eggs in the ground in the fall; they lay there all winter and come out a fly in the spring, which deposits eggs to make the worm. Male and female fly; copulate. They must eat; fly lives two or three months.

Answer by JAMES LOGGINS.—The caterpillar changes into some other insect—don't know what this is—which hides itself till spring and then comes out a fly; fly copulates; feeds on something; lives nine days.

Answer by JOHN LOGGINS.—The caterpillar burrows in the ground in the fall; it changes there to chrysalis, and in the spring comes out a butterfly; fly copulates; lives on juices of plants; exists about twenty-one days.

Answer by J. F. GROCE.—The fly goes into the ground or secretes itself in some hidden place in the fall to protect itself from winter's cold, and comes out in July and August to deposit eggs; no copulation; no eating by fly.

Answer by JOHNSON HENSLEY.—A small butterfly lays its eggs in the fall in old trash, leaves, or bark of cotton-stalks. These eggs remain intact during winter, and in months of June and July hatch out the worm. The fly copulates and eats juices of vegetation. First saw the worm in Washington County, Texas, in year 1834, on Milk Creek.

Answer by WALLER COCHRAN.—The caterpillar burrows in the ground; there changes into chrysalis, and in this condition stays till proper time to hatch out a fly. The fly copulates; does not eat; lives two or three weeks.

Answer by J. D. MITCHELL.—They remain in chrysalis state in any place suitable to protect them during winter; in spring it comes out a fly, which deposits eggs; fly copulates; subsists on juices of plants; lives fifteen or twenty days.

Answer by H. LEWIS.—They go through the winter in the chrysalis state. After eating up the cotton (1879) they took to the crab-grass in the cornfield and devoured it completely. Did not discover any change in the color of worm after eating the grass. The fly lives six or eight weeks.

Answer by Dr. E. MONTGOMERY.—The chrysalis is the medium of perpetuation during and through winter. The fly eats and copulates.

Answer by J. H. DAVIS.—The chrysalis for the most part turns out a fly, but sometimes a cross between a chrysalis and worm. This cross goes into the ground and into trash and lays there till spring, or a suitable time, when it comes out a fly. Sometimes, when the weather is not suitable, very few develop, and consequently we have very few worms. The fly does not copulate, and does not eat.

Answer by THOMAS ARMER.—The fly secretes itself in some warm place, where it hides till winter is over and warm weather comes to bring it out; male and female fly; copulates, but does not eat. Believes the worm eating up the grass is a totally different one from the Cotton Worm.

Answer by THOMAS RAY.—Believes they pass the winter in the chrysalis state; have frequently seen them plowed up out of the ground; male and female fly; fly lives about ten days. The worm now eating up the grass is a totally different worm from the Cotton Worm, it being of a green color and smaller.

LIVINGSTON, SUMTER COUNTY, ALABAMA,
September 5, 1879.

Maj. J. G. Harris handed me your circular and letter, with request that I should reply to the same. I herewith inclose my essay on destroying the Cotton Worm, written in 1873, which will give my answers to many of the questions.

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1. This county was occupied by the Choctaw Indians till 1832, and was mostly settled up by the white people in 1833, and rapidly cleared up and planted largely in cotton.

2. The first year of the worms was in 1842 (so far as I know), when they stripped the foliage from the cotton in September.

3. They are generally worse after a winter of even temperature, not very cold. Last winter was a very cold one, and the worms have worked about in patches through the two past months, but not extensively damaging the cotton, though the weather has been very wet, and the moths are now appearing in considerable numbers. We have them in damaging numbers one or two years, and then an intermission of two or three years, and sometimes alternating in different sections of the county.

4. Wet summers are much the most favorable for their multiplication. In dry, warm summers they do not multiply.

5. By the middle of May, but generally not till June, in their earliest but small generations. In 1873 the destructive brood—second or third generation—stripped the cotton of foliage in July and early in August; usually not till the last of August and September.

6. They generally appear earliest in "bottom lands" and prairie, where adjoining thick-set wood lands.

7. They hibernate in the moth state; and also the very late-formed chrysalis exists in that state through the winter, where protected from severe cold by grass or other herbage or covering, and perhaps in the ground.

8. All our insectivorous birds consume the worms, and the moths to some extent, but which are not out on the wing except at late evening and at night, or at a dark, cloudy evening.

9. No methods to destroy the moths have proved effectual; but fires attract them most, when some are burned or their wings disabled, and molasses will stick and hold some when attracted by a candle standing in the plate or vessel. This is the only known means of destroying the moth of the boll-worm, and preventing the great damage to the cotton crop by their more obscure depredations, and might be effectual to lessen them much by the persistent use of great numbers of these plates of molasses, with lamps or lanterns so made that they could fly into and be burned, and thus destroying them before laying their eggs in the cotton blossom. But sugar or sirups do not perceptibly attract by themselves.

10. These things are only useful in plates, when the moths are attracted by lights.

11. Know of no flowers which attract the moth, except the cotton blossoms attract the moth of the boll-worm, in which it deposits the eggs, one in each blossom; and these blossoms are expanding from early June to September which perfect cotton, and thence on into October, but which are too late to mature.

12. Know nothing of the influence of jute grown near cotton.

13. Know nothing better than Paris green or cheaper than arsenic to destroy the worms, but have an essay, in pamphlet, published in 1874, on "The Texas Cotton Worm Destroyer," discovered and patented by J. D. Braman and A. Robira, "which is a salt of arsenic that readily dissolves in cold water," "four ounces of which, dissolved in 40 gallons of water, and costing 25 cents, and sprinkled over an acre of cotton with a watering-pot or sprinkling-machine, will effectually destroy the worms and preserve the cotton." Patented by Robert Reunie in 1874. And they claim that it is better, safer, and cheaper than the other articles named.

14. Have not known of any injurious effects from the poison to men or animals, but heard of some through want of caution. The cotton leaves are quickly crisped and killed by the application of more poison than is necessary to kill the worms or in too concentrated a form.

15. The best methods of destroying the worms are given in the above answers and in my essay, and the most expeditious, with the cheapest, will be to use the poison in a dissolved form, and applied with *a fountain hand-pump*.

16. The cost per acre to protect a crop of cotton by killing the worms with poison will be from 25 cents to $1 and about half a day's work with the fountain hand-pump, to apply the poison in water, dissolved; or with sifters lined with muslin, to apply the poison in dry form, well mixed and incorporated with plaster or flour, when the cost of the flour may be added to the above-named cost, which was given only as the cost of the poison. What would be the cost of lamps, lantern traps, vessels, and material to destroy the moth, particularly that of the boll-worm, which does a vast amount of injury to cotton crops, or even to materially lessen the numbers, cannot now be estimated, as it has not been sufficiently tested. The fountain pump costs about $5.

Respectfully,

L. D. HOYT.

Prof. C. V. RILEY.

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PARISH OF CONCORDIA, LOUISIANA,
Lake Concordia, August 8, 1879.

1. About the year 1810 the planters of this parish and the adjoining county of Adams, most of whom owned property in both localities, commenced abandoning the culture of indigo, and substituted that of the cotton plant.

2. The first Cotton Worms or Caterpillars were noticed in 1840, both in this parish and in Adams County. They were noticed in August cutting the cotton in rank spots. The second crop stripped the rank cotton in September. The appearance of an heretofore unknown insect caused a meeting of all the leading planters, and it was generally agreed that, owing to the luxuriant rank growth of the cotton stripped by the worms, they were rather a benefit than otherwise, leaving the bolls exposed to the sun, and thus insuring their ripening. The worms again appeared in greater numbers in 1844 and 1846, doing considerable damage both years, especially in the latter year, as they stripped every field in the county before maturity. They continued to appear in numbers at intervals up to the breaking out of the war, but, as the culture of the cotton plant was pushed forward very early under the then existing system of labor, the yield was not much shortened by the stripping of the leaves in September, and many planters continued to think that the large cotton in new grounds, of which there was a considerable quantity, was benefited by the loss of foliage.

3. The character of the winter seems to have very little influence upon the propagation of the Cotton Worm; its development in greater or less numbers seems to depend *principally* upon the character of the summer season. A wet, rainy summer, causing a rank, succulent, growth of the plant, is peculiarly adapted to their propagation in countless numbers, even apparently shortening the period between their reappearance from twenty-one to eighteen days, and causing them to appear in such numbers in what is commonly called the second crop (in August) as to almost destroy the leaves on the cotton, and not leave sufficient foliage to sustain the next generation in September for more than half their allotted seven days. For instance, the winter of 1872–73 was one of the coldest known in this latitude for years. Worms were noticed in the latter part of May, and by the last of August the cotton fields of this parish were perfectly bare, and yet still another crop of worms hatched in latter part of September, and destroyed crops saved by application of Paris green.

4. Wet summers are almost essential to the reproduction in any great numbers of the worm. Many of the eggs do not hatch in dry weather, and then the many enemies of the worm have a better chance to destroy them.

5. In 1868, the first year of my experience as a planter, I noticed a few in spots about July 15. August 7 they were quite numerous in spots. August 25 they reappeared, and injured the crop considerably; worms green, with two rows of yellow, with black spots down back. September 8 a more numerous crop stripped portions of the field. September 25 the green, with black stripes down back, appeared, and soon stripped the plants of every leaf and small boll. In 1869 I found a few worms as early as June 24, full grown, pale green, marked with white and yellow spots. July 15 a few were noticed in rank cotton. August 7 they were quite numerous in spots of same character of cotton. August 27 the green and black spotted worm "chopped" the leaves badly over whole crop, and successive crops appeared each week, September 2, September 8; and then on September 20 the green and black striped worm commenced stripping the crop. This was a very wet season, cotton growing very large, and despite the loss of leaves, the yield per acre was about one bale of 400 pounds weight.

In 1870 the season was one of the driest ever known. I did not find worms until September 15, and then the green and black striped. They were not in sufficient numbers to do any harm. In 1871, the first worms noticed from 1st to 15th July, green; reappeared August 15, green, with black spots; September 10 appeared in considerable numbers, green, black striped, but did not entirely strip the plant; extremely wet spring, but dry summer. In 1872 the first noticed were on September 9, green, yellow stripes, black spots; reappeared July 15, all sizes and stages; August 20 to 25, heavy crop of green, black striped, stripping the cotton early in September. In 1873 found first worms latter part of May; had seen flies around buildings on warm days in February; did not pay much attention to their reproduction until July 25, when the green and black spotted ones appeared in considerable quantities. August 15 the green and black striped worms came in myriads, and made short work of the rank, succulent cotton, the growth of a rainy summer. I saved 900 acres by applying Paris green; 600 acres in one part of the parish was destroyed by October 1, the flies having been blown into my fields from adjoining plantations by a heavy wind the week previous; 300 acres on another plantation, being isolated, was not again molested.

In 1874 the first and second appearances were noticed latter part of July and August; September 4, considerable numbers of all sizes and grades; September 14, numbers sufficient to strip the cotton crop, as it was mostly planted after an overflow. Applied Paris green in places, but the worms disappeared, probably destroyed by birds and insects. In 1875, although not an unusually dry year, no worms were noticed.

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In 1876, found a few worms on July 12; August 2, considerable numbers in spots; August 22, reappeared in considerable numbers, all grades and sizes, but by September 7 they had mostly disappeared, it being very dry and hot, and birds and insects being plentiful. In 1877, noticed worms in July; August 10, good many; August 16, in sufficient numbers to justify use of Paris green in places, which saved that portion of the crop, but the worms reappeared in force September 20, and by 25th there was not a leaf left. In 1878, full-grown worms seen August 9, earlier broods not noted; August 21, full crop green, black spots, out over large area of the country, though not general; again used Paris green with success; September 12 to 19, cotton stripped. In 1879, the worm was first seen about June 20; about July 15 it was again observed, and now they are found through the fields in all parts of the parish, always the pale green, yellow, striped, and black spots. We look for a pretty full crop about 25th, and a destructive one about September 10, with continuance of this favorable showery weather, unless some natural causes, in way of birds or insects, prevent their propagation.

6. The Cotton Fly is a shy insect, and seeks shelter in large cotton, which grows in damp spots; there the eggs are deposited and the first worms hatched.

7. The moth hibernates between the bark of old logs and dead trees, in the lofts of barns, gins, and outbuildings, protected between shingles, or in crevices, in a state of torpor. Only a few survive the rigors of winter; hence the very few which appear in the early spring. It is my impression that the moth is impregnated in the fall, but this is simply a matter of conjecture.

8. Nearly all birds and fowls devour the Cotton Worm with avidity, but the common black-bird, which to a considerable extent hibernates in this region and breeds here, is the greatest enemy among birds. The common red wasp, the small red ant, a species of large green spider that I have never observed except on the cotton plant, a hexagon shaped bug, green and sometimes brown (it being apparently of a chameleon nature), flat and emitting a very disagreeable odor when roughly touched, armed with a long, sharp bill which it carries under the body—commonly called the pumpkin-bug—and lastly, the Ichneumon fly, all destroy the worm in its various stages of transition—the ant even taking the larvæ from the under side of the leaves. The wasp and Ichneumon fly, where numerous, seem to be most destructive.

9. The experiment of saving a crop from worms by destroying the moth was most effectually tried prior to the war when well-controlled labor was at hand and money was plentiful, and since then some enterprising men have spent much money and time in the vain attempt to save their crops by this means, but none in this section have succeeded. There are many, many times more worms hatched than necessary to complete the work of destruction; besides, my belief is that the moth deposits its eggs before leaving shade of the thick cotton, and having accomplished its destructive mission then flies about in the air.

10. The moth is attracted by the light, and my observation is that the vessels containing molasses, &c., being placed around the light, serve more to entrap than attract them. The moth is very destructive to fall fruit, puncturing it so soon as it begins to ripen.

11. Have never noticed moth about flowers.

12. Have never seen the experiment tried.

13. Arsenic itself is used by some persons, they claim, successfully, and, of course, as it only takes about one-quarter of a pound to an acre, it is the cheapest poison that can be used; but owing to the great weight and the perfect insolubility of arsenic with water, I have found it a very unsatisfactory application; first, unless incessantly stirred and shaken it precipitates and clear water is applied, and the Cotton Worm lives on.

Secondly, if too much is carried in suspension upon the cotton it burns all young bolls and leaves. The Texas Worm Destroyer, a salt of arsenic, has considerable reputation and does dissolve in water, but, individually, I have been unable to attain the happy medium of mixture—either the worms are not killed or the cotton is much burnt when applied strong enough to kill. A solution of arsenic known in this section as "Early Bird," and which dilutes readily with water, has the same objection—it has to be made too weak to kill worms or it kills worms and burns cotton at the same time. Hence I find myself compelled to adhere to the Paris green, even when run up to 75 cents per pound, as was the case in 1873. Have tried sundry other poisons without effect. Am now having prepared several solutions of Paris green with ammonia for experiment. As the great trouble is that Paris green will not dissolve in water—being only held in a state of suspension and precipitating so soon as the water ceases to be agitated—the water into which it is put has to be constantly stirred, and the 2-gallon pots from which it is sprinkled have to be constantly shaken violently; therefore we have been, so far, unable to use any mechanical process of sprinkling.

14. When applied too strong, say in greater proportion than 1 pound of green to 40 gallons of water, or 6 pounds of green to 200 pounds of flour and land-plaster, the mixture will burn and kill young bolls, forms, and tender leaves, and thus do as much harm

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as worms. Occasional instances of men being nauseated while mixing the green with flour and plaster, or even while sifting it on the plant, have come to my notice; but a single dose of the antidote, hydrated oxide of iron, always gave relief. A good many instances occur of men becoming chafed by riding, and the flour mixture and even the water getting on their persons causes soreness, and sometimes swelling of the parts accompanied by an eruption of white pimples; but this is soon relieved by the use of the antidote externally or an occasional application of sweet oil and sprinkling of flour. This trouble is prevented by use of oil-cloth aprons and free use of strong soap after working with the mixtures. Mules are sometimes made sore around and under the tail and on flanks and shoulders if care is not taken to wash them clean of the flour mixture, which becomes caked in the hair.

15. I have found the application of Paris green the *surest* poison for destroying the worm, applied in the early morning and late evening, mixed with flour and equal parts plaster of Paris and land plaster, 6 pounds green to 200 pounds, carefully and thoroughly mixed and sifted before using, and then sifted on each side of the row through a No. 24 sifter, and during the heat of the day when the leaves are dry, ½ pound to 1 pound green to 40 gallons water, sprinkled on each side of the row with a 2-gallon watering-pot, ordinary sized rose, perforated with holes about the size of a knitting-needle. The drawbacks the cotton-grower has to contend with are many. First, if the worms come early, say about August 1, in sufficient numbers to justify the use of green, the next crop, which comes about September 1, will destroy his crop; besides the work of cultivation is not completed. If they do not appear until 1st to 10th of September, he is then compelled to devote his time to picking the crop on sandy lands, and a loss of a week from this important work results eventually in great loss. If the worm appears in force about the middle of August the planter is then better prepared to destroy them, and the plant in a better condition to justify the expense; but often the weather is very showery, and much of the green is washed off, and the plant is partially stripped before the worms are killed; also, now that Paris green is so extensively used for this purpose, the article is very much adulterated, and while he pays less apparently per pound for it, it requires more of it to same quantity of flour or water, and even then it is not so destructive. Our great need is a *cheap, soluble* poison, which will dissolve thoroughly in water and kill the worm and not burn the cotton.

16. The cost of application, outside of first cost of the Paris green, depends upon a good many contingencies—convenience of water, size of cotton plant requiring more or less of the mixture to the acre. Where applied mixed with water and the water is convenient, as is generally the case in this parish, it will cost from $1 to $1.50 per acre. When applied mixed with flour and plaster (by far the most efficacious process) it will cost from $1.50, at the lowest, to $2.50 per acre. The best and surest plan for the cotton-planter to protect himself against the ravages of Cotton Worms is to list up his lands in December, and very early in January replow, plant early, and force the plant to maturity by constant, judicious cultivation. This mode costs as much per acre as the application of Paris green, but it is money better spent, as the soil is kept in better plight by such a process. Still, under favorable circumstances, I am a strong advocate for the use of Paris green, or any other efficient poison, to kill this worm, and use the green whenever my crops are threatened with injury by the worms.

Very respectfully yours,

F. S. SHIELDS.

C. V. RILEY, *Chief U. S. E. C.*

NATCHITOCHES, LA., *September* 29, 1879.

First, in order to answer your questions intelligently, I will give a slight outline of the geographical location and situation of the parish of Natchitoches. It is situate in the northwest part of the State of Louisiana, the greater portion being immediately south of the thirty-second degree of north latitude, its greatest length being from southeast to northwest. It had a population, according to the census of 1870, of 18,265. Had in cultivation last year, or rather in the previous year (1877), in cotton, 23,800 acres, and produced 13,949 bales of cotton. The lands are particularly fertile and productive, yielding the greatest abundance of the fruits of the earth with a small outlay of labor. As to your questions:

1. I answer only for the parish of Natchitoches, La. Cotton was first planted in this parish about the beginning of this century.

2. The first appearance of the worms in this locality was in the year 1823, late in the autumnal season, and they did but little damage to the cotton plant. The second time was in the year 1840, doing again very little damage, and creating no alarm in the minds of the planters; but when they came again, in the year 1844, they did considerable damage, causing serious alarm to those engaged in planting, making them

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ask the question if it would pay to continue the business. By the end of the month of August every leaf was stripped from the plant as if a killing frost had fallen. After this, confidence was restored and cotton planted extensively until the year 1846, when again the crop was destroyed. The damage was considerable, and the yield lessened at least 25 per cent. After this no particular attention was paid to the worms until after the close of the late war, since which time they have reduced the yield year after year, until they became so destructive as to almost deter planters from engaging in the business.

3. In order to answer this question intelligently I have obtained the following facts in regard to the appearance of the worm from the year 1867 up to and including this present year, 1879.

Rain for the months of April, May, June, and July.

	Inches.		Inches
1867	29 1/10	1874	17 3/10
1868	18 1/10	1875	7 1/10
1869	22 4/10	1876	9 2/10
1870	19 4/10	1877	20 3/10
1871	21 6/10	1878	15 1/10
1872	23 9/10	1879	16 1/10
1873	23 1/10		

As to the temperature of the months of December, January, February, and March, Dr. F. Johnson says: "As to mean temperature of these same months, the variation is too little to have any influence on the question before you. Compare your notes on caterpillars, and see if you can find any mutual connection between temperature, rains, and worms. I do not think there are any satisfactory bonds of connection."

Caterpillars in—

1867.—First appeared about 6th of June; destroyed crop last of July.
1868.—First appeared 1st day of May; destroyed crop 10th of August.
1869.—First appeared 20th of June; destroyed crop 20th of August, partially.
1870.—First appeared 20th of June; destroyed crop 20th of August.
1871.—First appeared 15th of June; destroyed crop 20th of August.
1872.—First appeared 20th of June; destroyed crop 20th of August.
1873.—First appeared 10th of June; destroyed crop 1st of August.
1874.—First appeared 20th of June; destroyed crop 20th of August.
1875.—First appeared 20th of June; destroyed crop 20th of August.
1876.—First appeared 20th of June; destroyed crop last of August.
1877.—First appeared 20th of June; destroyed crop 20th of August.
1878.—First appeared 15th of June; destroyed crop 25th of August.
1879.—First appeared 20th of June; did not destroy crop.

4. This question is answered by the preceding answer so far as figures can, and from the statistics it appears that weather has no particular influence on them. You will observe that the months of April, May, June, and July of 1869 were among the wettest of the caterpillar years, yet the crop was only partially destroyed, and for the same months of the year 1876 we had nearly two-thirds less rain and the crop was destroyed as usual. As to their destruction by the ants, that will be more fully explained later on. The plant during a dry spring is of very slow growth, and may not be able to furnish the necessary *pabulum* for the life and growth of the worm. This might be accounted one of the causes of a wet year favoring their development; there is more surface and food for them in a wet spring than in a dry one.

5. They have frequently been seen as early as the first days of the month of May, notably in the year 1868, when they appeared in great numbers in some localities, and did considerable damage to the cotton plant. Many planters were much alarmed at this early appearance, and thought themselves ruined again. The plant was, however, yet young and recovered from the damage, and a pretty good crop was made.

6. In the low moist places when the cotton is greenish and more tender.

7. The insect undoubtedly passes the winter in the butterfly form, which is the fourth and last stage of their existence. They belong to the species *Lepidoptera*, and genus *Papilio*, and are the proceeds of the chrysalides from the caterpillars. They are about seven-eighths of an inch long, of a dark grayish color, not so pronounced on the under side of their wings, with a characteristic dark circular spot on each wing. The last seen of the caterpillar in the autumnal season, when the crop of cotton is destroyed, is in the form of the chrysalis, for after they eat all of the cotton leaves they proceed to "web up" on any leaf that will afford them protection. This chrysalis produces the butterfly, which immediately prepares for hibernation. It is my opinion that they seek winter quarters before they mingle in concourse with the males, hence their eggs are not fertilized until after they come from their torpid state in the spring of the year. They may be seen in the warm days of January, February, or March, near the eaves of

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houses covered with shingles, or in corners of fences made of rails with the bark on them. Just before sunset, after one of these warm days, they will come out and fly around. At this time they do not possess the same brilliant colors that they do in spring and summer when they are depositing their eggs, and one not perfectly acquainted with them might mistake them for another species. They therefore pass the winter in the butterfly form, in a semi-torpid condition; yet, strange to remark, *en passant*, the first thing seen of them in the spring of the year is the worm itself.

8. First, birds (*Aves*) of various kinds and conditions feed more or less on them; among others I will mention the mocking-bird (*Orpheus polyglottus* of Linnæus). This bird feeds extensively on the Cotton Caterpillar (*Aletia xylina*) in the early months of its existence; but they are not gregarious, hence their work is little appreciated in this direction, they not being disposed to go in flocks or localize or concentrate their destructiveness.

This present year (1879) the Cotton Worms have not developed as rapidly and as numerously as they have done usually heretofore, and among other causes retarding their progress has been pointed out as their great enemy the red-winged black-bird (*Agelæus phœniceus*). This bird has been seen in large flocks in the cotton-fields very early this year. These birds have been seen frequenting our fields and forests in great numbers late in the autumnal season, but have never been known here in the months of July and August before. One planter told me that he saw one flock of at least forty thousand in the cotton-field! This number may have been considerably exaggerated, but there is no question that they have been in the cotton-fields during these early months, July and August, in very great quantities, such as have never been seen before. I have been informed that they feed upon the worms in three of their forms, the butterfly, caterpillar, and chrysalis. These birds should be protected and permitted to build their nests undisturbed by the hunter's shot or idle boy's hand. Many other solitary birds feed upon them, but their work is not appreciated.

As to quadrupeds, there are none known, with perhaps the single exception of the raccoon (*Procyon lotor*). He has been seen feeding on them, and planters inform me that they have seen the tops of the stalks bent and broken, evidently the work of the coon in search of the caterpillar.

Insects. Ants (family *Formicidæ*, order *Hymenoptera*) have always been looked upon as one of the most inveterate enemies of the Cotton Caterpillar, destructive to them in all of their four different forms. They will detach the egg from the leaf and bear it off to their formicary; attack and kill the worm either in its active eating state or when under the torpidity of the second or chrysalis state, and if it is possible for them to capture a butterfly it shares the same fate. It may be owing to their inability to procreate and move about during wet weather that the worms are enabled to escape their depredations. It is a well-known fact that the female ant is winged, hence it is plain to be seen that wet weather will considerably interfere with their proper functional office. The female ants are furnished at their exclusion with two pairs of wings, which after swarming in concourse with the males they almost immediately cast. The office of the perfect or winged female is to provide a constant supply of eggs for the maintainance of the population. Rainy weather can therefore keep the female ant "cribbed, cabined, and confined" to her prison life; if she is permitted to venture forth it is possible for her to be lost in the storm. The suberabundant surface-water remaining after heavy rains will greatly impede the active operations of the "neuters," or working ants, whose office it is to supply and protect the colony.

The wasp (genus *Vespa*, order *Hymenoptera*) attacks the worm, and will carry them off to feed their young, and should they be so unfortunate as to drop one on the ground *en route*, the ants will be certain to pick it up.

There is a small chinch-bug constantly found on the cotton-plant leaf, which undoubtedly feeds on the ova or eggs of the butterflies. They are not numerous, however, and are too small and insignificant to do any great amount of damage or interfere materially with the rapid increase of the worms.

9. The only effort ever made in this parish to destroy the butterflies has been by fires at night. They are easily attracted by the "glitter of a garish flame" at night, and great quantities can be destroyed in this manner. It, however, requires concert of action on the part of a large number of planters, which has never been done. As to attracting them by sugar, &c., it is generally believed that the butterfly does not take nourishment during its short life, or, if it does, the quantity is too small for them to be successfully poisoned.

10. They will be attracted only by the lights.

11. I do not know of any flowers that will attract them. They are not seen on any other plant than the cotton.

12. Nothing.

13. Nothing.

14. First, as to the plant: If the mixture is put on too highly concentrated it will kill leaves, blooms, and bolls. Second, as to man: When any portion of the cuticle is abraded and the mixture allowed to get on this particular place, it is apt to cause local

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inflammation and inflammation of the neighboring lymphatic glands; no case, however, to my knowledge, has ever been known to result seriously. Third, as to animals: I know nothing of any serious accident to them.

15. The best method yet tried is the application of the Paris green suspended in water, 1 pound to 40 gallons. The Paris green being the arsenite of copper, it is not soluble in water, and when the two are mixed the Paris green is only suspended; hence it is necessary to keep the mixture constantly agitated, otherwise some portions will be stronger than others, and will in that case be apt to injure the plant.

The mode of applying it differs according to the means of the planter using the poison. Many persons make brooms of the Mayweed (*Anthemis cotula*), which are handy and very convenient; others use the common garden watering-pot with the perforated nozzle, which is expeditious, efficacious, and at the same time inexpensive. The best mode yet found is with the fountain-pump; with this the work can be accomplished with neatness and dispatch without wetting the clothes of the one applying it. The poison must be applied just after the worms are hatched and begin to crawl, otherwise it will be too late. It requires careful looking to find the worms at this stage of their existence. Four or five days after the butterfly emerges from the chrysalides she begins to lay her eggs, on the under side of the leaf, and after about the same time the eggs begin to hatch; then look carefully under the leaf in the locality where you expected to find them, and almost to a certainty they are there. In order to better find them every planter should provide himself with a small magnifying glass, which will cost him only about twenty-five cents. This summer I had in my office one leaf from the cotton plant, and on it there were ten worms and in it at least one thousand holes, yet on handing it to several persons they failed to see either caterpillars or holes until they were pointed out to them.

By request I received the following letter from one of our largest planters:

NATCHITOCHES, LA., *September* 26, 1879.

DEAR SIR: In 1876 I experimented with arsenic to destroy caterpillars, with the following result: I took one pound of 16 ounces of commercial arsenic, which cost about 25 cents per pound, dissolved it by boiling in 8 gallons of water; after it was dissolved replaced the quantity of water lost by evaporation; with this 8 gallons I went to work. 1st. Put 2 gallons of the solution in a pork-barrel of water, say 33 gallons, sprinkled two rows of cotton; result of this application was death to both cotton and worms. 2d. I then used 1½ gallons to the barrel of water; same result to the worms, cotton badly scalded. 3d. I then took one gallon of the solution and put it in a barrel of water; this time my solution seemed to be a little too strong, but did no perceptible injury to the plant; the leaves retained their color except in places. A fourth application of three-quarters of a gallon of the solution to a barrel of water was tried and found of sufficient strength to kill the worms and not damage the plant. These experiments were made at the same time Paris green was applied to the balance of the cotton on the plantation, none, however, being used when the arsenic was applied. The rows in which the last two applications were made (*i. e.*, 1 gallon and ¾ gallon to the barrel of water) the cotton lived and bloomed about three weeks, at which time the worms destroyed all of the cotton on the plantation.

Respectfully,

H. B. WALMSLEY.

DR. GEORGE E. GILLESPIE.

The Paris green has been sold in this market for $1 per pound, but it can now be bought for from 25 to 35 cents per pound. It is calculated that three-quarters of a pound will poison an acre; however, if the application is made just before a rain, it will be necessary to repeat it. Most planters think that $1 per acre will cover all the necessary expenses.

Respectfully,

GEO. E. GILLESPIE, M. D.

C. V. RILEY, *Chief U. S. E. C.*

JACKSON, MISS., *September* —, 1879.

In answer to some of the questions of your circular No. 7:

4. Warm, wet, and cloudy weather favors the appearance and reproduction of the Cotton Caterpillar.

5. Never have known them to appear in the spring when June and July have been wet; the 1st August is about the earliest period in this locality.

6. In cotton of the largest growth without regard to the situation.

7. Observation has led me to believe that the worm in none of its forms lives through our winters in this locality, and also form an opinion in direct variance with science as taught in the schools. I have attempted to arrest their increase when only a few

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had made their appearance by destroying by hand, but without success; for suddenly, without the possibility of such an increase by reproduction, they would appear in such numbers as to destroy every leaf in two or three days. Again, in another instance, when no worms were in this neighborhood, four days after a diligent and careful search, when no sign of them could be found, they suddenly appeared, and in three days not a cotton leaf could be found in my field except about one acre near the middle of it, which was planted much later than the rest, not a leaf of which they touched, although some of the branches interlocked; but some weeks afterwards, when this patch of cotton had arrived at the same stage of growth, it was also stripped of its leaves as the other. In all my observation, the worm when it has exhausted the supply of cotton leaf *will eat nothing else*, but crawls up on the weeds, bushes, and fences, and dies.

8. From this experience, connected with the facts of their irregular appearance, and that only under the same conditions of wet, warm, and cloudy weather, which is always unfavorable for a healthy growth of the cotton plant, and that the worm never appears in the spring or early summer, at least not in such numbers as to be noticed; its power of quick reproduction; its total absence from the cotton plant at that time when it could not escape detection; and the temperature of May and June always high enough for the development of the worm through all its forms, leads me to believe that the Cotton Caterpillar is the spontaneous production of diseased cotton plants.

9. All efforts to destroy and stop the progress of the worm when the condition for its appearance and increase is favorable has proved futile so far as my experience extends in the cultivation of cotton for thirty years.

Yours, very respectfully,

H. O. DIXON.

Prof. C. V. RILEY.

LARISSA, CHEROKEE COUNTY, TEXAS,
October 13, 1879.

In answer to your 4th inquiry, viz: "Do wet or dry summers favor its multiplication?" I would answer that about ten years ago the Rev. N. A. Davis, now of Jacksonville, in this county, suggested to me the probability that the small red or brown ant, abundant in the South, was the natural enemy of the Cotton Worm, and especially effective during dry summers. After two summers' observation, I was convinced of the truth of the reverend gentleman's conclusions. His opinion and two years' observation induced me to write the following to one of our county papers:

THE COTTON WORM (1871).

"The danger from the Cotton Worm is now over and we may review the history of its depredations during the summer. Only a few farmers have suffered save in the anxiety which they have felt during the maturation of their crops. If you recollect, the worm was worse during the few weeks following the rainy season; and as the dry season since advanced, the worm gradually receded and the hopes of the farmer revived. The first generation of these troublesome insects appeared to have taken place in the wettest lands early in the spring, and it was about the second generation that menaced the crops. Wet weather favors the increase of the worm and dry weather soon destroys it. This observation has been made by many farmers long ago. A similar observation has long since been made in regard to the Cotton Louse. Early in the spring (when the cotton is in its first and second leaf), if the weather is rainy, the louse soon covers the tender cotton plant and threatens to destroy it. But when the dry season supervenes the little insect disappears, and the plant soon recovers from the mischief. To what shall we attribute the disappearance of the insect in both cases? It is evidently due to that little predatory and almost omnipotent ant which retreats to its hole and gathers in large bunches in dry places during the rainy seasons; but whenever the drought sets in, it climbs the stalk of every plant in search of prey. It is carnivorous and deals death and destruction among insects in the crawling stage of existence wherever it goes. When the Cotton Louse multiplies dangerously on the tender plant, favored by a rainy season, the farmer loses all hope of his crop, unless the dry weather comes and the little ant begins to milk the cows (the lice are called 'ant cows') by climbing up to them and striking them with their hands, and eating a fluid which is made to exude from them by the concussion. This process soon destroys them. Then, at a later season, especially if the ant is driven to its shelter by rains, the Cotton Worm, having increased to a dangerous extent, threatens the more mature plant. Again the same ant, when the sunshine permits, saves the cotton by climbing the stems and seizing the flouncing worm, cuts it into two on the ground, to which both have fallen in the struggle, and thus in a very short time it thinned out the worm, either destroying or holding it in abeyance.

"The history of these two enemies of cotton-growers accords with the experience of observers. The dry weather, *per se*, does not save the cotton from louse or worm in

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the former or latter season only as it permits the predatory ants to destroy them; nor does the wet weather favor the production of the insect only as it drives the ants to their holes. Were it not for the ant the cotton plant would never make the first limb, or, escaping this, could not mature a single boll on account of its second enemy, the worms.

"Then let us curse the little biting ant no more when we happen to get a shoe full, but remember that we are indebted to this diminutive creature for every thread of cotton that has gone into the commerce of the world."

Thus you see that about ten years ago the Rev. N. A. Davis informs me of his discovery of the destruction of the Cotton Worm by the ant; to which I have added the additional fact of the destruction of the Cotton Louse earlier in the season by the same ant. The observation of each succeeding year since that time has confirmed me in the opinion, and our last summer, the driest I ever saw, yielded no specimens of the worm or louse within my observation. Please obtain the technical name of inclosed ant.

Yours, respectfully,

F. L. YOAKUM.

Prof. C. V. RILEY.

PERRY COUNTY, ALABAMA, *September* 17, 1879.

I beg leave to offer the following, in answer to your questions in regard to the habits of the Cotton Worm, and the best modes of destroying the same:

1. I can remember seeing cotton grown as far back as 1820 in Autauga County, Alabama. Since 1822 I have been cultivating the plant in Perry County, on sandy land.
2. In 1837, about the middle of September, was the earliest I ever saw them. No damage of any consequence afterwards until 1866.
3. In my opinion, the worms are worse after a severe winter. I suppose it is because they come out oftener during mild winters and are consumed by the birds.
4. Hot, dry weather seems to be the life of them.
5. The 20th June is the earliest I have noticed them, but doing no serious damage until 20th July.
6. They invariably make their appearance first in the low, black lands of West Perry County.
7. They hide themselves in old barns and rotten trees during the winter, coming out in the afternoon of warm days.
8. The appearance of the worm does not seem to attract any kinds of birds to our fields, but all domestic fowls devour them ravenously, as do also hogs and ants.
9. There has been no method adopted for destroying the moth successfully.
10. They are attracted in larger numbers by decayed fruit of almost any kind than by anything I know of (during night).
13. Paris green seems to be the most reliable mode of destroying them, though some of my neighbors have used London purple with good effect.
14. It is dangerous to men, animals, and cotton when used with indiscretion.
15. I have used kerosene oil, one part to thirty parts water, effectually, and spirits of turpentine will do about as well. I believe pine sawdust sown *lightly* with the seed would be a preventive.

Yours, &c.,

O. H. PERRY.

Prof. C. V. RILEY.

WALTERBOROUGH, COLLETON COUNTY, SOUTH CAROLINA,
September 28, 1879.

I mail you this day my report, as requested by you in circular No. 7. This report is not as full as one I made last year to the Department, but what I have said is founded on experience and close observation of the Cotton Worm for years.

Trusting that it may be of some use in your department,

I am, very respectfully, yours, &c.,

JAMES W. GRACE.

C. V. RILEY, *Chief U. S. E. C.*

1. Cannot state from any reliable authority, but cotton was grown soon after the settlement of the county, for domestic purposes.
2. As early as 1793 the worm swept over the State, but it is first recorded in this district in 1800 as prevailing generally.
3. The worm is most to be dreaded after a mild, warm winter. He will make his appearance sooner in the following season.
4. Wet summers by all means favor its multiplication.

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5. First of June.

6. In wet, low spots where the plant grows luxuriant, the plant being succulent, soft, and pulpy.

7. I believe that it is a peculiar parasite of the cotton plant, and as such that the cryptic germ of the insect is to be found with the germ of the plant itself, and, like all parasites, only requires favorable circumstances to develop it; a soft, pulpy, and luxuriant state of the plant, with cool and cloudy weather at the time of its natural advent—that is to say, from early in June to middle of July—will cause it to develop vigorously and bud rapidly, so as to produce seasons; whereas dry June and hot weather, causing a hard, dry state of the leaves and mature condition of plants, furnishing but little and poor food, will result in a poor and feeble brood, too inactive to do harm. This theory is borne out by the following facts: The Cotton Worm is found everywhere on the globe where cotton is planted, and only found on the cotton plant. The worm will starve if the cotton plant fails, though other vegetation abounds. When the plant is pushed on so as to grow and mature rapidly, the leaves being hard and dry in June, as was usual before the war, we hear nothing of the worm; but when cultivation is bad, the plant backward, and when June, the time of its natural development, comes, the worm finds the cotton (as since the war) green, sappy, and soft; then does it rejoice in wholesome food, increase rapidly, multiply, and make itself a scourge.

I do not believe that the worm is migratory and returns to us from a warmer climate every year, for it can be found every year in small numbers if sought. I cannot admit this view, as I have seen it 300 miles from the coast at an elevation of 1,500 feet, in the northwestern corner of this State, in the month of June, and observed it there till the fields in August were totally destroyed. How could I believe that it got there by migration or was carried by currents of air? Nor can I believe that it hibernates around, as under old fences, on the south side of stumps, &c.; as, first, our winters are too severe to render such a supposition plausible; and, again, since the late war, no fences exist to give such shelter on the islands of our coast, where the worm most prevails, and the universal fires that pass every fall over woodland and clearings would effectually destroy any moths or chrysalids.

Therefore it is clear to my mind that it is a peculiar parasite of the cotton plant, and the cryptic germ of the insect is to be found with the germ of the plant itself.

Last year I made a very full report of this matter, and am sorry to learn that it was made no use of, and probably consigned to the paper-mill without being read.

8. Almost all birds, such as the mocking-bird and others, seem to be fond of the worm.

9. Paris green is the only thing that I have seen used, except fire-stands about the field. The latter is useless. Paris green is good, and the only thing I know of that will destroy them.

10. I should say near fire-stands.

11. I don't know of any.

12. Nothing.

13. There has nothing been found better than the Paris green to destroy the worm.

14. I have not. With care there is no danger to man or beast.

15. Good cultivation. Push the plant early in the season.

16. The cost of keeping a good man and paying and feeding good hoe-hand, and this is the best means, and the cost is not very much.

JAMESTOWN, ALACHUA COUNTY, FLORIDA,
September 16, 1879.

In answer to your circular questions, the following is respectfully submitted:

3. The worm is most dreaded after mild winters.

4. Much rain in June and July seems to favor their development; but the character of the rains in those months in this section are short but frequent showers, with bright sunshine between showers. The writer has come to the conclusion from some observation that continued cloudy days are unfavorable to the development of the worm, and these reasons are given: Continued cloudy days are unfavorable to the hatching of the eggs; the sunshine seems to be needed with its greater heat. In cloudy weather the flies or moths will be on the wing throughout all hours of the day, thereby giving the birds and mosquito-hawks better opportunities to catch them. In such weather the worms stay on the top side of the leaves throughout the day, and consequently are more readily seen and caught by their enemies; while in hot, fair weather the moth is concealed during the day, and does its work in the twilight and at night, when the birds and other enemies are at rest. The worms, too, of the first crops seem to work or eat only in early and late parts of the day, and probably at night; generally from 8 or 9 o'clock a. m. till 4 or 5 o'clock p. m. they will be found quiet on the under side of the leaves. It is the belief of the writer that continued

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rains, with cloudy days, are unfavorable to the increase of the worm; cloudy days, even without rain, are unfavorable.

5. Have never seen the worm earlier than June.

6. Generally is seen first in moist, rich spots, where the cotton grows rapidly.

7. Have seen the moths at various times during the winter as "candle-flies." Suppose that those worms that come to maturity when winter is approaching, by instinct seek some place protected from cold, and, if not disturbed, might remain in chrysalis till the proper amount of heat would develop them into the moths. Those that are badly or slightly protected from cold may either be frozen by cold weather or warmed into life by a few warm days, while those that are properly protected, which probably are but few, will pass through the winter, and be revived only by the hot sun of May or June.

8. Almost all domestic fowls will eat the worm. Geese will eat them to some extent, while chickens, turkeys, and guinea-fowls will grow fat on them. Almost all wild birds will eat them, and a large wasp, both black and red varieties, seems to be fond of the worm. In this section there are great numbers of a lace-winged fly, commonly called mosquito-hawks. These are of various sizes and colors, and are very expert in catching the moth on the wing. I believe this mosquito-hawk is very influential in preventing the progress of the worm.

While on this question I would like to state that it is my opinion that much good could be accomplished, and probably many fields might be saved, if birds that are insectivorous could be domiciled in the field. From what I have heard of the English sparrow it occurs to me that this would be the bird for the purpose. If bird-houses are located in various parts of the field, the birds would naturally hunt for insects near their homes, and the consequence, I think, would be that in all cotton fields well supplied with these birds the caterpillar would be kept down. If the English sparrow can be domiciled, that is, will stick to its house and feed around, it could be made of great benefit to the cotton region. The suggestion is offered for your consideration.

Very respectfully,

F. M. McMEEKIN.

C. V. RILEY, *Chief U. S. E. C.*

SAN ANTONIO, TEX., *September* 11, 1879.

I shall not answer your questions as I find them in the Herald of this city, for I presume there will be plenty of answers for you. My object is to state a fact bearing on the Cotton Worm. I planted cotton in the State of Nueva Leon, Mexico, five leagues below the city of Monterey, in 1867. Cotton had never been planted at the place, nor nearer than 200 miles to it, in this world's history. I brought the seed from San Antonio, Tex., the ordinary Petit Gulf seed. The genuine Cotton Caterpillar appeared in the last days of May, and by the end of June ate up the crop. In the city of Monterey, at the same time, I planted in my garden (a large one) two patches of cotton—one the Texas seed, the other the black seed of the Sea Island genus, that is generally planted in Mexico. The distance between the two patches was, say, 200 yards. I received a note from my partner at the hacienda below Monterey, about 10 o'clock in the morning, telling me that he had discovered the worm in the cotton field. I at the moment passed into my garden and *found the worm in both patches.*

Now, the question is, where did they come from? The egg or germ could not have been in the seed, as the butterfly cannot reach the seed to lay her eggs, and the gin would have destroyed them. I assert that they could not have been blown there, or have remained deposited in the earth from the creation thereof; yet they came. The weather was showery, hot, sultry, and between showers a hot sun. I have planted cotton all my life; have noticed the worm, and have always found them to come after such weather as I describe. When you walk between the rows after a shower, and a sort of hot steam vapor comes up, then look out for the butterfly. I also planted cotton in the Laguna, or Rio Nazas country, in the State of Durango, Mexico, in 1873–'74–'75–'76, where we plant the black seed but once in five or seven years; as a general thing the same Cotton Worm to which I have been accustomed in Texas came every year; but, as there is but little rain there, they seldom come before September, and too late to do much harm. Scientists say there is no original creation possible now; that all things of this world had their beginning when it was made; but I believe that the atmosphere created the germ right there. When I was a boy there were no Cotton Worms; now they never fail. These are points to which you are devoting your time, and so fraught are they with the interests of our people that all will wish to aid you as they can; and I write this to state a fact, but which I know will add to your difficulty.

Respectfully,

H. P. BEE.

Prof. C. V. RILEY, *Chief U. S. E. C.*

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SAN ANTONIO, TEX., *September* 29, 1879.

You do not agree with my theory, but it will bother you to find out where the Cotton Worm came from, under the circumstances, as stated in my previous letter.

There is no cotton growing *wild* in the part of Mexico where I resided, as there are heavy frosts there every winter; in the tropical region of the State of Vera Cruz, and to the south large crops of cotton are raised, but I never saw a *wild* cotton plant.

The consul at Vera Cruz could, I have no doubt, give you an interesting account of the cotton plant in his section. I know that in the neighborhood of *Paso del Macho*, on the Vera Cruz Railroad, the cotton is bent down so as to stand the storms, and consequently the plant grows horizontally instead of perpendicular, and presents a curious appearance when ready to pick.

Some years ago there were large fields of cotton in the State of Coahuila, in the district of Monclova, but although admirably adapted to the production, the Cotton Worm from successive visitations entirely broke up the business, and now no cotton is planted in that State.

I planted cotton for four years on the Rio Nazas, or laguna country, in the State of Durango. This is the *Nile* of America. The Nazas rises periodically (always once a year, sometimes oftener), and overflows a vast extent of country; a bold, clear mountain stream, 200 miles long, finally emerges from the mountains into an immense plain. The banks become lower as the river descends, until by many mouths it winds its way into the lake or laguna, a body of water 90 miles long and 35 wide, with no outlet—a great body of fresh water on an elevation of, say, 3,000 feet, in the midst of a great dry desert. The water of the lake is not utilized, as the soil on its banks is poor, no alluvial deposit or growth denoting original formation, but rather that the lake had been produced there by some convulsion of nature, as, if it were the original deposit of the waters of this great river, there would be swamps and sluices and timber denoting that fact, as the mouths of the Red River and other streams in Texas and Louisiana. The haciendas of the laguna begin where the River Nazas emerges from the mountains, and is utilized by dams and canals and ditches, by which the overflow is restrained and the land irrigated. This irrigation is seldom used more than once a year, as the extraordinary character of the alluvium deposit of centuries retains moisture sufficient to produce crops for two years if necessary. (It seldom rains, and rain is not depended on at all for crops.)

Cotton is planted once in seven years; is planted with a hoe. A hole is dug from 12 to 18 inches deep, to the moisture, the seed deposited, and that is the start, which is expensive, but there is no other way, as the moisture is too low down to be reached by a plow. The cultivation is as with us: Frosts kill the plants, the stalks are cleared off and burned, and in the early spring, with the budding of the peach tree, the cotton sprouts, and gives you a start of three or four weeks over seed just planted. The "Planta" gives the best yield the third year; gives less, but a good crop, the fourth and fifth; and then produces as in the first and second years. The seed planted is the *black seed*, like the Sea Island and Egyptian; staple long and fine. The green seed, or American cotton seed, yields the first year better than the black seed will on the third year, but as that seed will not rattoon or grow again from the roots, and the expense of planting is so great, it is not generally used. Cotton produces a bale to the acre; corn and wheat most extraordinary crops in these rich alluvials.

Cotton is planted at Santa Rosalie, in the State of Chihuahua, but not to a great extent; the climate is almost too cold. This gives you all the information I have about the cotton region. With the exception of the Nazas and the Santa Rosalie, no cotton is grown in Mexico, except in the tropical regions of the Atlantic and Pacific coasts, as the rest of Mexico is generally table-land, with an altitude of from 3,000 to 7,000 feet, and a temperature too low for delicate vegetation.

There is a mountain in the center of this vast alluvial plain of the laguna. In caves in this mountain are to-day the bodies of an extinct race of Indians, of whose existence in this plain there is no history extant. The bodies or mummies I have seen; they are wrapped in a species of cloth or matting made from the maguez, painted, and all in good preservation; the skin has dried, the hair is perfect; all in wonderful preservation. No iron, gold, silver, or other metal has been found in the cave. Pottery ware, of the same shape as the pictures we see of the old Egyptians, arrow-heads, and spear-heads of flint. It really is remarkable, and induces the belief that some sudden overflow of the river submerged the plain and drowned all the people; they were evidently used to high water, as they buried their dead in the caves of the high mountains. There are thousands of mummies in these caves. Excuse this long letter.

Yours, respectfully,

H. P. BEE.

Prof. C. V. RILEY, *Chief U. S. E. C.*

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KIRKWOOD, MISS., *September* 5, 1879.

1. The cultivation of cotton, I am informed, was coeval with the settlement of the country. I settled here in 1845 and found cotton cultivated all over the county.

2. The Boll Worm has been an annual visitor since the first cotton was planted, destroying more or less, according to the character of the season. Though I had heard of the visitation of Aletia previously, I first observed it in 1858, though it did but little damage to crops that year.

3. It is more dreaded after a mild winter, but its visitations do not seem to be influenced more by one than the other; that is, they are as often seen after one as the other.

4. Cannot say that a wet season favors its multiplication. They are never developed during hard rains or continued wet spells. Their propagation seems to depend upon showery weather creating atmospheric dampness, and a high mean temperature. Dry weather is unfavorable to their production or increase.

5. The last week in July is the earliest period. Have often found, what is here called the grass worm, as early as May, eating both grass and cotton.

6. Its first appearance, in my observation, is along hill-sides where moisture is retained, and hollow spots on upland, just where in plowing after a season the plow encounters the wettest soil; such spots as generally produce the most luxuriant cotton.

7. About the middle of last November, and after several severe frosts, I found many chrysalides, of the last brood, on bare cotton stalks, living and lively. I placed these with others, previously brought in, in glass jars and boxes with earth and rubbish, exposed to outer air. Between the 15th and 20th of January, after a severe freeze of several days' continuance in December and January, a number of living moths came forth, in a warm spell then prevailing, but soon died. On the 6th of February the whole lot of chrysalides were then examined, when many were found to be dead and dried up, others again look plump, which were inadvertently thrown away, and from the cases of others several varieties of living ichneumon flies were taken alive. One of them filling the case, and of normal size, was sent to Professor Riley and pronounced by him to be "*Pimpla conquisitor*," a parasite of Aletia. My impression now is that had they been left undisturbed the living moths would have issued forth this spring from a few.

I do not think the moth can survive the winter, as in its natural state and in confinement it is so short-lived in the summer, and my conclusion is that though it may be retarded in its transformations in our climate by cool weather, it was not designed by nature to hibernate in any of its phases, but is the creature of a semi-tropical climate, where it is perennial and completes the cycle of its existence uninterruptedly. It has followed cotton, its favorite food, into our temperate climate, has become indigenous, but has been subjected to abnormal changes, and only appears in large numbers during those periods when our climate assumes for a time a semi-tropical aspect.

Many of the moths leave their cases late in the fall, and many eggs as well as chrysalides are caught by the frost upon the cotton stalks and must necessarily fall to the ground with the detritus of the plant, and where there is much vegetable matter, as is the case in our fresh lands, and from the decomposition going on, would be well protected against frost. What goes with the moth, unless it dies, is a mystery, as I have rummaged everywhere without success, and in spite of rewards offered can hear of none from one season to the next. The general opinion is that they die out.

As the egg of the *Aphis*, a much more insignificant insect, but one greatly affecting cotton, is known to survive the winter, by analogy I do not see why the egg of *Aletia* may not likewise survive. The one, *Aphis*, is deposited on the stalk, and the other, *Aletia*, on the leaf; both go to the ground. *Aphis* appears almost coetaneously with cotton under its appropriate law, and why may not *Aletia* appear later from its ovum under its appropriate law?

8. Starling and a species of gregarious blackbird; ichneumon flies, and also a small, velvety-looking caterpillar, black, with two lateral yellow stripes.

9. Poisoned sweets near lights for the destruction of the moths were tried here many years ago, and with some success. It was soon abandoned on account of the time and trouble, as well as expense, and has never been repeated. A moth-lamp attracted attention a few years since about Canton, but that, too, has flickered out.

10. Light would prove far more attractive than the sweet.

11. I know of no flower which attracts them.

12. Nothing.

15. As we usually, in fact invariably, see the worm before we see or hear of the moth, the aim would be to destroy the second brood, and this could be best done by putting out lights and sweetened poisons to attract the moths.

I will here reiterate what has been submitted in previous correspondence, that the propagation of the worms in destructive numbers is the result of imprudent tillage, and that by plowing wet land we hasten their production by an artificial process which good husbandry would teach us to avoid. He who will run his plows only

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when his lands are in good tilth and the work will prove advantageous to the plant cultivated, will never have his cotton injured by the invasion of the Cotton Worm. I deem it unnecessary to go into detail, as my theory and plans have been elaborated in previous correspondence.

I have the honor to be, yours, respectfully,

E. H. ANDERSON.

Prof. C. V. RILEY, *Chief U. S. E. C.*

[Dr. Anderson's theory, referred to in the above report, and as set forth in an extensive correspondence, may be thus stated: In 1858, in the month of July, on visiting his cotton field early in the morning, he found his overseer running a number of plows on a hill-side adjoining bottom land, where the soil was wet. He ordered the plows to be stopped, believing that the work would fire the cotton and cause it to shed, and perhaps injure the land by baking the wet sod in the hot sun. In ten days the worm was discovered in the cotton, and in twenty days there was not a leaf or young boll to be found upon it, and what especially surprised him was that the worms did not touch adjoining cotton or cross the plowed furrows. Since that time he has often witnessed a similar occurrence, and others have had a like experience, so that he gradually came to consider that there was cause and effect. He made experiments which seemed to confirm that belief, and finally reached the conclusion that either the moth, unobserved, had deposited her eggs upon the stalks, or the eggs of the previous season had fallen to the ground with the leaf of the plant and, being protected by the detritus, had survived the winter. To use his own language:

"Under ordinary circumstances, from the albuminous nature of the egg, it would be affected by heat and moisture naturally; that is, by solar action on rain and dew, creating vapor, which quickens it into life, by inducing fermentation and putrefaction, without which no egg could be hatched and no germ vivified. Under the influence of cold these chemical forces would be dormant, and the embryo or germ would remain quiescent. The necessary atmospheric conditions do not recur annually for the speedy propagation of the *Anomis*, and hence we do not have them in destructive numbers except in propitious seasons. * * * It is a fact, patent to all practical farmers, that, if their land is plowed while wet or too wet for good tilth, the corn or the cotton, as the case may be, is injured thereby—fired, as it is termed; the corn turning yellow and being arrested in its growth, while the cotton sheds its leaves and droops. Why is this? I should say because the clod is exposed to rapid solar evaporation, and the hot steam damages the plants, through its respiratory organs, and impedes the normal functions of all of its organs by disturbing the healthy equilibrium of the air. That an abnormal degree of heat is produced by this process is proved by the application of the thermometer, as I know by experiment; and every farmer knows that the hottest and most oppressive work is plowing wet land under a hot sun." It cannot need proof to show that when by plowing you disturb the capillarity of the earth while damp, abnormal heat is produced by the more rapid evaporation of the upheaved soil. This is as certainly true as that a shower, by restoring or re-establishing capillarity, will cool down the earth.

"Now, my theory is that the damp artificial heat produced by the process of plowing wet land is the most favorable of all conditions for hatching speedily the eggs of the insects, and especially when you add to this the extrication of ammoniacal gases, which under such circumstances must be more abundantly evolved. This I hold to be the solution of the mystery of speedy generation in the wetter portion of cotton fields."

The plan of prevention Dr. Anderson proposes on this theory is, never to run the plow in May or June south of his latitude, or in July or August farther north, when the land is wet and not in good condition for plowing. If there are frequent rains, he believes it matters little when or how the plowing is done; "for so long as the rain continues the necessary physical conditions cannot be produced—shower succeeding shower in rapid succession keeps the temperature of both air and earth cooled down and is inimical to the worm. When, however, showers at longer intervals occur, and the temperature is high, and the plowing produces rapid evaporation, and the plowman, reeking with sweat, pants for a breath of pure, dry, fresh air, then the *Anomis*, nurtured into life by its genial surroundings, commences its revels, and in a short while the luxuriant cotton is converted into bare and blackened stalks."

"You must make cotton as you make hay; that is, while the sun shines. The diligent farmer who keeps even with his work can always afford, without detriment to his crop, to let his plows rest until he can do good work, but if plow you must, to kill grass, and the rain won't stop, throw your furrows into the middle of your rows and not to your cotton, as by this process the danger of developing the worm is less, and no injury is done to your plant.

Dr. Anderson, nevertheless, admits that "a few of the insects are annually hatched by a natural process; enough to perpetuate the species." A similar theory to this one of Dr. Anderson's is held by a number of planters, founded, of course, on the ob-

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served influence of soil and weather on the development of the worm; but in so far as any such theory implies the hibernation of the egg, or the spontaneous generation of the insect, or in so far as it departs from the reasoning on pages 81-83 of this Report, we believe it to be fallacious.]

[The following condensed summary of the habits of the worm is from that excellent observer, Dr. D. L. Phares, of Woodville, Miss.:]

The caterpillar generally makes its first appearance at or about the same spot in a field year after year, partially or wholly denuding a few square rods or an acre or two. That is the first appearance *generally* noticed by planters. Close observers find a few earlier, and only a few leaves nibbled on only a stalk or two of cotton. In due time the moths from this first, or rather second, brood deposit their eggs in all parts of the field when the foliage is in right condition for feeding the young. In a few days more all parts of the field are stripped simultaneously, that is, so far as eaten at all. This when the destruction is early. When broods are smaller, the successive generations appear for three, five, and even seven months.

"They are not Army Worms. They usually hatch and pass through all transformations on the same plant on which the egg is deposited. If accidentally thrown off, they return to the plant when practicable. Sometimes violent storms of wind and rain sweep nearly all off and wash them up in vast heaps against fences, &c., where they putrefy. Dry, hot sunshine seems to destroy them in all stages; and sometimes, under such conditions, they abandon the partially denuded plants and move in immense masses from the field; not so often, it seems to me, for other food, as to escape the intense heat. Under such conditions one rarely ever ascends another cotton plant. Their march is to death. If a road be in the way and dusty, and still worse sandy or gravelly, few succeed in passing the barrier. The exposed hot ground kills them, and sometimes we have seen them in the road-side ditches several inches deep, infecting the air with putrefactive stench.

"Another point: If the moth deposits no eggs in any part of a field, no caterpillars will attack that part. She knows evidently where the young can subsist and where not, and she deposits her eggs accordingly. If the plant is in condition to feed the moth, I suppose it is in condition to hatch and feed the young. Little or no difference is perceptible by the common planter in the condition of the plant on two sides of a line that may divide an injured and uninjured field. A little distance from the line the difference is not perceptible. The plant is not so tender. Its chemical and mechanical condition both unfit it for the food of the caterpillar; therefore the moth deposits no eggs on it, nor will the caterpillars if placed on it eat it. This is specially and annually noticed on rolling or undulating lands, and sometimes on lands to the eye apparently level. This is my fortieth crop on the lands where I reside, and in no year has my whole crop been eaten off. The crops are often destroyed in Madison County and other points north as well as south of me before any damage is done here by the caterpillar. This depends on condition of plant."

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NOTES.

"200."

NOTE 1 (p. 1).—"ALETIA ARGILLACEA. Aus Bahia. Vom Herrn Sommer abgelassen. Eine *Noctua genuina* und *Heliophila lineata*. Sie ist der *A. Vitellina** sehr ähnlich, hat aber in nichts eine Gleichheit mit ihr und auf den Schwingen einen weissen Punct. Ihre Fürbildung 399, 400, stellt ein *männliches Muster vor*.

"* Hübn., Noc., 379. Vitellina."

This may be translated: "From Bahia. Left by Mr. Sommer. A *Noctua genuina* and *Heliophila lineata*. It is very similar to *A. Vitellina*, but is in nothing identical with it, and has a white dot on the wings. Figs. 399 and 400 represent the male."

NOTE 2 (p. 1).—Without entering into any general discussion, which would be out of place here, as to whether Hübner's names should be adopted or not—a question which has always divided entomologists—but following those who, taking the more conservative view, accept his species when his descriptions and figures leave no question as to what is intended, the above purported description, in connection with the figures, would have to be rejected even from this standpoint. In point of fact they leave every doubt as to the species intended, and give us no absolute certainty. The only descriptive part is that referring to the white dot, and this is conspicuously and well represented on the figure referred to; but it is this very character which makes it morally certain that some other species than *xylina* Say was intended; for while typical specimens of *xylina* invariably have the three white minute dots referred to on page 9 of this work, the conspicuous discal or reniform spot on primaries is almost invariably oval and dark, with two cinereous pupils, which are often dilated so as to represent a large cinereous spot, with a dark center and a dark border. Of the many hundreds, and we may say thousands, of specimens which we have examined, not one has had the distinct white spot described and figured by Hübner. The figures in other respects bear out this conclusion; for while in the different copies of the Zuträge the coloring will vary according to the colorist, and according as the colors have changed with age—two facts which in themselves should be sufficient to discard names founded on mere figures—yet in the three copies which we have examined the figures represent a smaller, feebler-bodied species, lacking in the characteristic olivaceous hues, and much more roseate superiorly and more highly colored with yellow and roseate on the under side. The under surfaces of *xylina* are of tolerably uniform pale gray, with a faint ochreous tinge, and in no specimen of *xylina* do we find the sharp black line on the under side of the hind border of the secondaries characteristic of Hübner's figure.

From these facts it will be seen that nothing can be absolutely settled from Hübner's description and figures, and so much has this been felt by previous authors that they have not been able to identify Hübner's *argillacea*. Thus Guenée, who had evidently better material to judge from than any previous, or for that matter subsequent, author whom we can call to mind, questioned whether his *grandipuncta* (=*xylina*) could be referred to *argillacea*, for the reason that this last is more yellow, more distinctly marked, with the reniform concolorous, marked with a very distinct white dot, and quite distinct on the under surface. Even Mr. Grote, notwithstanding the assurance with which he identifies *argillacea* in the paper before the Association in the fall of 1874, expressed his uncertainty in his first published opinion on the subject earlier in the year. (Bulletin of the Buffalo Society of Natural Sciences, vol. i, p. 170, 1874.)

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The figures on our Plate IV, 7a, were kindly copied for us by Mr. Edwin Sheppard, from the copy of the Zuträge in the library of the American Entomological Society. The coloring has been slightly lightened in the printing, but otherwise shows the figures very well as they appear in that copy. In the copy in Dr. Hagen's possession,* as also in that which we have lately obtained for the Department of Agriculture, the figures are somewhat darker; but all are uniform in those particulars which we have just pointed out, and in which they differ from *xylina*. Hence, a careful and candid study of the subject, so far as Hübner's work permits, leaves very grave doubt as to the identity of his *argillacea*, and though from the fact that we had accepted Grote's determination in the first edition of this work (solely on his authority) we have tried to retain it rather than make a change in this second edition; yet an unbiased weighing of the facts presented by the published data would alone have forced us to reject *argillacea*. We are entirely of Dr. Hagen's mind, as expressed in a letter written to us April 4, 1883, after full study of the facts, and before he was aware of our previously published opinion to the same effect. He remarks: "Compared with Say's excellent description, I believe it out of question not to accept Say's name, which has priority."

Forced thus from the published data to reject *argillacea* on the groundof uncertainty, we have endeavored to reach a definite conclusion from non-published, historical data, *i. e.*, by an endeavor to ascertain whether types of Hübner's *argillacea* were still in existence. Dr. Hagen kindly informed us, in a letter dated April 12, 1883, that since *argillacea* was described from the collection of the late Mr. Sommer, of Altona near Hamburg, it might perhaps be possible to find the type specimen still in that collection, as Mr. Sommer had his collection specimens kept in very good order. The Sommer collection was supposed to have been purchased by the Museum of the city of Hamburg, but upon inquiry we were informed by Mr. C. Crüger, who was formerly connected with the Museum Godeffroy of Hamburg, that the collection had long since been purchased by Dr. Staudinger, of Blasewitz near Dresden. Having thus traced the Sommer collection, we directed Mr. A. Koebele to proceed, with specimens, to Germany, and to visit Dresden and inquire into the facts. With the kind permission of Dr. Staudinger, Mr. Koebele was able to make an examination of the Sommer collection, but the results gave us no greater certainty; for from the notes made it would appear that very few of the labels in the Sommer collection are written by Sommer. The collection is, also, in great disorder, and has been neglected by Dr. Staudinger. Of the eight specimens of our *xylina* in the collection one is marked from Panama, another from Porto Rico; one is named "*Anomis grandipuncta* Guen.," another, unspread ♀ specimen "*argillacea* Hbn., and a third "*A. grandis*." If there were any way of considering these labels authoritative the evidence might be considered in favor of our *xylina* being Hübner's *argillacea*, but from all the facts it is evident that the labeling has been done by other hands, and there is other evidence to weaken the value of those labels. Thus the type of *argillacea* is distinctly stated by Hübner to be male, so that the female above referred to could not be the type, which must also have been spread to have permitted the artist to fully figure the upper and under surfaces of all wings. Again in the Sommer collection there are eight specimens of a closely allied moth—the *Anomis luridula* Guenée, of which one is labeled "*luridata?*" and a second "*modesta*" and a third "*exacta*." The species is quite unlike the *exacta* of Hübner's figures, so that we have here positive evidence of the worthlessness of the labels as historical indications of Hübner's types.

NOTE 3 (p. 5).—It may seem strange, but nevertheless there is no published detailed description of the earlier states of this insect that is at all full and accurate, or that will permit the entomologist to discriminate between the species and some of its closer relations. Say's original description of the imago is sufficiently full and satisfactory.

*This copy, as Dr. Hagen informs us, is on "geschöpftes Papier" with what is known as old coloring in good condition.

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and there are many general descriptions of the egg, larva, and pupa, several of which, especially where accompanied with accurate figures, will serve to identify the species on the part of those who have not previously become familiar with it. But of the egg and the different larval stages, and even of the pupa, there are no such technical descriptions as will enable the entomologist to discriminate between these different states and those of some of the closer related species. This is particularly true of the early larval stages. Dr. C. W. Capers is usually referred to as having given the earliest full descriptions of egg, larva, and pupa, and in order to indicate how very general those descriptions were and how thoroughly they are lacking in the characteristic structural details, we reproduce the descriptive portion of his otherwise excellent article published in 1828. His description of the egg would apply more truly to that of *Chrysopa*, from which it was probably drawn.

[From the Southern Agriculturist and Register of Rural Affairs, vol. i, for the year 1828, Charleston. Art. II.—On the Cotton Caterpillar, by Dr. C. W. Capers, of Saint Helena Island, pp. 203–209. Portion quoted, pp. 204–208.]

"I have not been able to ascertain the exact period when the cotton caterpillar first made its appearance in this country; but the earliest intelligence of them which could be gathered from the best planters, of their destroying the cotton, was in the year 1800. The accounts given of insects of a prior date destroying the indigo and other plants, were undoubtedly of another species. In the year 1804, their numbers were so great, as to nearly destroy the cotton crops; but a storm, which arose on the 8th of September, proved so destructive to them, that they were not seen in any great numbers, as far as I can learn, for many succeeding years; and, although in the course of a few years they were to be found on many plantations, yet, the injury done by them was not very general or great in amount;—and it was observed, that certain plantations, and even certain spots upon it, were the first to be visited by them. In the year 1825, they commenced very early, and were spreading rapidly, when they were again cutoff by the storm which took place on the 14th of September. Immediately after the storm, I went into the cotton fields, and could see a small numbers of the caterpillars still remaining; but in the course of a few days, they totally disappeared, and it was confidently trusted by the planter, that the elements would once more relieve him from this devouring insect, and was, in this manner, consoled for the loss sustained. But this proved fallacious, and the following year the crops were more rapidly and effectually destroyed than in any which preceded it. The earliest notice taken of them was on the 1st of August, at a plantation upon this island, and soon afterwards they were found in various parts of it, and information received, that they were in all directions upon the sea-coast from North-Carolina to New-Orleans.

"On the 23d of September, they had consumed nearly all the cotton leaves, all the upper pods, and some of the latter of a size almost ready to open. At this time they quitted the cotton plants, and the whole earth seemed to be a moving mass and completely alive as these insects crawled along on its surface. A few of them remained upon the cotton stalks, but, in consequence of their want of food, they changed their color and became dull and languid, and finally perished. I have never been able to account, satisfactorily, for the sudden manner of these insects quitting the cotton plant. It was not for the purpose of webbing, for most of them were young; and when they web, it is always on the cotton stalk, or some neighboring plant, unless when it is for the winter. Nor was it, in all instances, for the want of food; for, in most fields, there were certain spots which they had left untouched. The only reason which I could assign was, that having consumed the leaves from the cotton, they were directly exposed to the sun's rays; which, from a meteorological journal I at that time kept, were observed to be very powerful. Whatever the true reason might be, such is the fact, that they appeared to leave the cotton simultaneously, and in the course of a few days, but a small number of these myriads were anywhere to be seen. We have, every year since, had them in particular places, but not in such numbers as to do much mischief. Their early appearance in the summer months, much depends upon the temperature of the preceding winter; and this must, of course, influence their numbers, which will be more fully explained when giving a description of the habits of the insect.

"The *Noctua Xylina* is an inhabitant of the seacoast of our southern country. How it first came here, whether by flight, as some have supposed, or brought in the chrysalis, a thing much more likely, I am unable to determine. The changes which the different insects undergo through the successive stages of their brief existence, are familiar to most persons. Nothing can be more unlike than the worm crawling upon the earth or on the plant, and feeding upon its leaves and tender parts, and the moth or butterfly to which it has been converted, expanding its brilliant wings in the air, or passing from flower to flower. These changes form a complete circle, multiplying

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each time in such wonderful progression, as would soon overwhelm everything by the increase were there not certain causes by which they are destroyed, and once more brought back within more reasonable limits.

"*The moth* will be noticed the first in the series. It is a small insect of a triangular form, about 1 inch in length, and is easily distinguished from all others which bear any resemblance, by the peculiar dark spot upon its superior wings. It seldom moves in the day-time unless disturbed, but at night its flight is rapid, and it is often attracted into houses where there are lights. How many days after leaving the pupa state, it is before the moth lays its eggs, or how many of them, I am unable to say.

"*The egg* is of a bluish green, and quite small. It is generally deposited upon the under side of the cotton leaf, and is about fourteen or fifteen days in hatching. It is confined to the leaf by means of a small filament, attached by a glutinous substance.

"*The caterpillar* or *larva*, when hatched, is so extremely minute, as to be scarcely perceptible to the naked eye. In a few days, however, it attains its full size, which is about 1¼ to 2 inches in length, and about the thickness of a crow quill. The color is not always the same—some being much darker than others. All, however, are marked with black spots upon the back, and lines of the same color running the whole length from head to tail. The belly is of a light greenish yellow, and when about to web, it swells, loses the spots, and becomes of the same colour as the belly. As I before noticed, the sun appeared to have great effect in changing the color, or it was produced by the scantiness of the food, as it was only those of a light color who were able to remain upon the stalks after the leaves were consumed in the year 1825. It is well known, that the caterpillar avoids the sun, and it is principally in cloudy and damp weather, and during the night that they thrive best, and consume most food. At such times, when they are in large numbers, they can be heard at the distance of several yards whilst feeding and moving about on the cotton plant; and so offensive is the effluvia arising from them that this is generally the first indication of their presence, and so peculiar is it, that whoever has noticed it once will rarely mistake it when he again approaches them. Their activity, also, is remarkable. Upon being touched they double themselves up, and spring to some distance. In feeding, they always commence with the upper leaves; afterwards they take the larger leaves, and finally, the blossoms and young pods, and in 1825 they were compelled to resort to older pods and the bark of the stalks. I have never seen them eat any food besides the cotton plant. In the year just mentioned, when they had completely denuded the cotton fields, excepting a few spots as before noticed, and were compelled to quit for the want of sustenance; they took their way through the corn-fields, pea, and potato patches; and although they webbed in each, and all of them, indiscriminately, yet the greater part perished on the earth for want of food. We may therefore conclude, that these insects never devour anything but the cotton plant; and that the caterpillar which destroys the corn, the potatoes, peas, and grass, are totally different, as any one may see, who takes the trouble of examining them. The latter resembles it more closely than any other, but it is of a much lighter color, and although nearly as large around, is not more than half the length. The rapidity with which these insects increase, and the short time it takes to consume a large field of cotton, is truly astonishing. They not only do material injury to the cotton plant, by destroying the young fruit, but by the destruction of the leaves, the plant itself is injured, or a new growth caused, which essentially injure the larger pods, causing some to open prematurely, and others, in consequence of a want of sap, to perish without ever expanding.

"Added to this, they injure the ripe cotton, by the dirt and filth which they cause, and by webbing in the cotton itself, as they frequently do, either stain it by being mashed in it, or when hatched, the shell of the pupa remains, and passes through the gin rollers along with the cotton. In about fifteen days they begin to swell, and rolling up a leaf by means of filaments which they attach to it, they completely envelope themselves, and in this manner pass into the pupa. It is not a matter of any consequence what leaves they use, but in general they resort to the cotton leaf, or those growing in its neighborhood; and it is not an uncommon thing to see several thus webbed on one leaf, or to see a twig where every leaf has one embedded.

"*The pupa* is of a dark chocolate or chestnut color. When touched, if alive, it always moves its joints. They remain in this state from fifteen to eighteen days, when the moth makes its appearance. This is during the summer; but when they web, for the last time in the fall, the larva retires to the woods or some convenient place, where, uniting several dried leaves, it attaches them to a limb by means of a filament, 2 or 3 feet in length, and retiring into its cell, passes into the pupa, which remains in this state until the ensuing spring. The exact period of their hatching, varies according to the temperature of the winter and spring months; and it is undoubtedly for this reason that they retire to the woods, which being of a more equal temperature, does not expose them so much to the cold, and they are also protected from the violence of the winds.

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"When these insects first appeared, various attempts were made to destroy them; but so rapid is their increase, that nothing done by the hand of man, has been able to diminish their numbers, so as to be in the least perceptible. Nor is it probable that anything will destroy them, excepting such causes as have already been related; viz. powerful storms of wind and rain, and their own prodigious numbers destroying their food before the completion of the summer season. The Palma-Christi and Bennè have both been said to keep them away from the cotton, and I have known them planted for that purpose about the cotton fields, but without producing any good effect; and I believe that the planters are now satisfied that they are useless."

Descriptions of the earlier states of Aletia xylina (Say).

Egg.—Diameter 0.6mm, plano-convex, circular. Around its center are grouped three series of elongate either pentagonal or hexagonal cells, the middle series largest, this central area or micropile subpentagonal; radiating ribs quite sharp and somewhat wavy, from 35 to 40 in number, and about half of them more or less shortened; cross ribs 12 to 14 in number. Color, at first a delicate bluish- or sea-green, becoming a more dingy yellowish-green when near the hatching period. Empty shell white, glistening and transparent.

Larva. *First Stage.*—Length when just from egg 1.4mm; quite slender. Head immaculate, much larger than joint 1. Legs very long, except first two pairs of prolegs, which are rudimentary and scarcely perceptible. Color almost white, with a faint tinge of green. Head pale yellow, ocelli black. Piliferous warts blackish (see Fig. 2, p. 6), each giving rise to a slender dusky hair.

Second Stage.—Length just after molt 3.6mm, similar to previous stage, except that the warts of the body become more distinct, and that the characteristic black spots of the head appear, 11 each side, each furnished with a stiff blackish hair. The rudimentary legs are also somewhat longer.

Third Stage.—Length 6mm. In this stage the final markings, or those of the full-grown larva, begin to show, though there is much variation in color. The most strongly-marked individuals have a broad, deep black, mediodorsal stripe, bordered each side by a fine, clear white line; the sides and venter are whitish or yellowish-white, the sides often slightly dusky and with a faint indication of the white sub-stigmatal line; stigmata very small and dusky. Head orange; piliferous spots with a white or yellowish annulus.

Fourth Stage.—Length 9mm. Colors bright and lines more distinctly contrasting. In the dark specimens, a narrow black line borders the white subdorsal, the sides are more dusky, and the pale supra-stigmatal line more distinct.

Fifth Stage.—Length about 16mm. Coloration similar to that of the previous stage.

Sixth or last larval Stage.—Length when full grown 38 to 40mm. Slender, tapering somewhat toward both ends. Head small, round, free. Legs of normal number, but the first pair of prolegs atrophied. Head more or less orange or ochre-yellow, marked with 30 regularly arranged black spots; antennæ 3-jointed, the first joint large, conical, fleshy; second joint shortest, often not visible, being withdrawn into the first; third joint slender, about as long as the first, slightly thickest toward apex; its tip obliquely truncated, bearing a small subjoint, a short slender, fleshy tubercle, and a long bristle and a shorter hair at its outer extremity. Ocelli 6, clear, colorless: mandibles strong, pale yellowish or greenish; tip blackish, with rather dull teeth. Color of body variable. Black stripes and markings of the dark specimens are deep velvety black. Normal color green, with longitudinal lines of a white or yellowish color, as follows: A fine medio-dorsal, a rather broader sub-dorsal, and coincident with this last and about the same width, a supra-stigmatal, and, finally, a sub-stigmatal, the distance between the last two being about twice that between the previous two. In the pale specimens the medio-dorsal white line is almost always relieved by two black lines, or rather by a black border on either side, but the whole dorsum is more or less dusky, and in the darkest specimens it may be, including the cervical shield, quite black, as also interspaces between the lateral lines. The supra-stigmatal line in the darkest

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specimens broadens at the sutures, producing thereby a row of more or less distinct yellowish, slightly swollen spots in the region of the stigmata. All warts surrounded by a white annulus, those on dorsum sometimes obsolete. Stigmata brownish with white annulus. Anal plate yellowish with a transverse row of four larger black spots, and four smaller ones at posterior margin. All legs yellowish.

PUPA.—Average length, 18mm. General color dark brown; posterior, flexile portion of abdominal joints 4–6 dark yellow; head, thorax and wing-sheaths very finely and closely granulate; abdomen also finely granulate, the granulations concave in the center; flexile borders very finely punctate. Head rather small, well set off from the thorax. Wing-cases broad, reaching to posterior margin of the fourth abdominal joint. Cremaster dark brown or blackish, ample, parallel, rounded at tip, slightly bent ventrally where there is at base an anal concavity; rugose, with strong carina dorsally, extending to base of terminal joint; hooklets yellowish-brown, eight in number, two dorsal and two lateral short, and four terminal which are longer, the middle pair longest.

NOTE 4 (p. 6).—In alcoholic specimens the first pair often appear as mere tubercles without clasping hooks, but these really exist, though withdrawn from sight. The legs are perfect, therefore, and simply atrophied. In this respect the larva of *Aletia xylina* (Say) differs from that of *Anomis texana* Riley, which occurs in South Texas, for in this last species the claspers are wanting and the legs really obsolete and replaced by mere tubercles. Otherwise the resemblance between the two larvæ is such as to cause them to be easily confounded.

NOTE 5 (p. 7).—The larva of *Plusia dyaus* Grote is not uncommon in spring and early summer on cotton. Being a semi-looper and bearing in color and mode of pupation a general resemblance to the Aletia larva, it is often mistaken therefor by planters. It is invariably pale green, without dark shades, and may have helped to the popular belief in the first worms being green. But while we have invariably found dark individuals among the earliest and throughout the summer generations, we were struck during a trip made October, 1879, through Mississippi, Alabama, and Georgia, by their great preponderance, the intensity of the black (often obliterating the white annuli and subdorsal stripes), and the early stage of growth (often after the first molt and very generally after the second) in which it appeared. In the spring and early summer the black is more often confined to the fifth and sixth stages.

NOTE 6 (p. 7).—The young larva of *Spilosoma acrea* makes somewhat similar but larger blotches.

NOTE 7 (p. 8).—Mr. Schwarz succeeded in feeding one from the hatching period till it transformed to chrysalis on a species of Morning-glory (*Ipomœa commutata* Roem. & Sch.), but the chrysalis was imperfect, and finally perished. We find that quite a number of persons believe that the worm feeds on Abutilon and Pokeweed (*Phytolacca*), but the belief rests solely on the fact that these plants are often defoliated when the Cotton Worm is stripping the cotton fields. In the case of Phytolacca it is an entirely different worm (the Geometrid *Philereme albosignata* Packard) which does the work, and the same is doubtless true of the Abutilon. Mr. Phillip Winfree, of Mulberry Creek, La. (De Bow's Ind. Res. of S. & S. W., 1852, p. 173), remarks that it feeds in the West Indies on a plant called the salve bush, resembling somewhat the common Mullein. There is great liability to error, however, in observations of this kind, on account of the great resemblance in the earlier larval stages of several closely allied species. This subject of possible food-plants of *Aletia xylina* is more fully considered in Note 15 of this same report.

NOTE 8 (p. 9).—The male genitalia in this species are remarkable for having two extensile organs, usually retracted and showing as dense tufts of hair, but capable of extension to thrice the length of the rest of the armature; also for two attenuated double-jointed spines which lie when at rest in a sheath on one side of the penis,

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with the points extending beyond it, but which in action bend back at right angles therefrom. (See also Note 28.)

NOTE 9 (p. 10).—See the article, *Nectar: what it is and some of its uses*, by William Trelease, published in the Report upon Cotton Insects, Department of Agriculture, 1879, pp. 319–343. In this article the author discusses especially the extra-floral nectar glands of the cotton plant and their relation to Aletia. He concludes that the glands of the cotton plant seem to have been produced to secure the protection of the leaves and flowers of the plant from leaf and petal eating insects, like ants, but at the same time, since the introduction of the Cotton Worm, the glands have become injurious to the plant by attracting the moths at night, which alternately sip nectar and oviposit upon the leaves. The tendency now would naturally be to remove the glands by natural selection, but this is opposed by the methodical selection of man, who in his desire to produce a good staple and a vigorous growth pays no attention to the power for secreting nectar, and as this function does not cause any drain on the energy of the plant, it stands no chance of being removed.

NOTE 10 (p. 12).—Referring to the extreme rapidity with which the broods follow one another in midsummer, we made use of the following paragraph in our address before the Atlanta Cotton Convention, November 4, 1881 (see Bibliographical list):

"The first worms appear much earlier than was formerly supposed, viz., from the middle of April till the middle of May, in the southern portion of the cotton belt. The fact that these early worms generally attract no attention, and that the species seldom acquires disastrous force till the third generation, has given rise to the erroneous notion of later first appearance. There are also many more generations than has been supposed, seven or more being produced toward the Gulf, the last enduring till frost cuts it off. When I tell you that in addition to this rapid succession of broods the moth is one of the most prolific with which I am acquainted, capable, in fact, under favorable circumstances, of laying six or seven hundred eggs, you will no longer wonder at its destructive capacity. The progeny of a single female may, in less than two months, under the influence of midsummer temperature, reach twenty billions, while you all know that half a dozen worms to a plant are sufficient to jeopardize the crop. Why, were it not for the various natural checks upon the increase of the species in geometrical ratio, successful cotton-culture, with all our improved methods for destroying the pest, would be utterly impossible. Remove the barriers and the flood comes. The occasional impotence of the natural checks, through one cause or another, very quickly gives the Cotton Worm the mastery in the struggle for existence, and precipitates it upon us in multitudes almost as if by magic."

NOTE 11 (p. 12).—This is well illustrated by a fact communicated by Dr. D. L. Phares, of Woodville, Miss., viz., that the worm usually begins its work of destruction in Madison County from three to six weeks earlier than in Wilkinson; the former on latitude 33°, and the latter resting on 31°. At Madison station, in the southern part of Madison County, the thermometer marked the extreme low temperature of —4° F. during the winter of 1878–'79, while at Woodville, only about two degrees farther south, the lowest temperature noted was 14° F., or a difference of 18°.

NOTE 12 (p. 12).—In this connection we quote the following note on hibernation from the *American Naturalist* for April, 1883. It is a brief abstract of a paper read by us before the American Association for the Advancement of Science at the Montreal meeting in 1882:

"THE HIBERNATION OF ALETIA XYLINA, SAY, IN THE UNITED STATES A SETTLED FACT.—I have already shown in previous remarks before the association that there were various theories held by competent men—both entomologists and planters—as to the hibernation of this Aletia (the common Cotton-Worm of the South); some believing that it hibernated in the chrysalis state, some that it survived in the moth state, while still others contended that it did not hibernate at all in the United States. I have always contended that the moth survived within the limits of the United

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States, and in this paper the fact of its hibernation, principally under the shelter of rank wire-grass, is established from observations and experiments made during the winter and spring of 1881–'2. The moth has been taken at Archer, Fla., during every winter month until the early part of March, when it began to disappear, but not until eggs were found deposited. The first brood of worms was found of all sizes during the latter part of the same month on rattoon cotton, while chrysalides and fresh moths were obtained during the early part of April.

"The fact thus established has this important bearing:

"Whereas upon the theory of annual invasion from some exotic country there was no incentive to winter or spring work looking to the destruction of the moths, there is now every incentive to such action as will destroy it either by attracting it during mild winter weather by sweets, or by burning the grass under which it shelters. It should also be a warning to cotton-growers to abandon the slovenly method of cultivation which leaves the old cotton-stalks standing either until the next crop is planted or long after that event; for many planters have the habit of planting the seed in a furrow between the old rows of stalks. The most careful recent researches all tend to confirm the belief that Gossypium is the only plant upon which the worm can feed in the South; so that in the light of the facts presented there is all the greater incentive to that mode of culture which will prevent the growth of rattoon cotton, since it is questionable whether the moth will survive long enough to perpetuate itself upon newly sown cotton except for the intervention of the rattoon cotton."

NOTE 13 (p. 13).—These observations have been made more particularly upon the Army Worm (*Leucania unipuncta*) and the Rocky Mountain Locust (*Caloptenus spretus*), and bear, of course, upon the successive hatching within the limits of hibernating regions rather than upon the northward spread of the insects outside of these limits. (See Eighth Missouri Entomological Report, p. 47, and First Report United States Entomological Commission, p. 232.)

NOTE 14 (p. 13).—Dr. Phares is the only writer who has, so far as we can learn, recorded as many as six generations from July 6, 1869, till frost.—*Rural Carolinian*, i, p. 695.

NOTE 15 (p. 15).—In reference to this subject, we quote the following on the possible food-plants, published by us in the *American Naturalist* for April, 1882, pp. 327–328: "One of the most interesting characteristics of the Cotton Worm is that it is so strictly confined to cotton as its food-plant. All attempts hitherto made to discover additional food-plants have proved futile, nor have we been able to ever make it feed successfully on other plants allied to Gossypium.* We have, however, long felt that there must be some other wild plant or plants upon which the species can exist, and this belief has been all the stronger since it was demonstrated two years ago from observations made by Dr. P. R. Hoy that the larva may occur in Wisconsin, and, consequently, out of the range of the cotton belt.† We have given special directions to those in any way connected with the Cotton Worm investigation to search for such additional food-plants, but so far no additional food-plant has been discovered. Last November we received from Dr. J. C. Neal, of Archer, Fla., specimens of a plant with eggs and newly-hatched larvæ which he believed to be those of Aletia, but which belong to an allied species—the *Anomis erosa* Guen. The plant proved to be one of the Malvaceæ (*Urena lobata* Linn.), which is reported as quite common in that part of Florida and further south, being a tall, branching, and straggling weed with annual stems and perennial root, from which new shoots arise in January. It blooms from February to December, and is a valuable fiber plant, the bark of both stem and root being very strong, and used very generally for whip and cording purposes. The leaves have three very conspicuous saccharine glands on the principal veins toward the leaf-stem, and the plant, Dr. Neal reports, is much less sensitive to

* The only partial success in this line is that already referred to in Note 7.

† See Report on Cotton Insects, Department of Agriculture, 1879, p. 89.

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cold or frost than Gossypium. We find that the plant has been received by Dr. Vasey, botanist of the Department of Agriculture, from several parties in Florida, with inquiries as to the value of the fiber. *Urena lobata* was, until very recently, not known to occur in the United States. It is common on dry hill pastures almost everywhere in the West Indies and southward to Guiana and Brazil, and is also reported from Western Africa, East Indies, China, and some of the Pacific islands. It seems to thrive very well in Florida, and is likely to spread to other adjacent States.

"The *Anomis erosa*, the eggs and young larvæ of which were not uncommon on the leaves of the Urena, may be distinguished from Aletia by the paler, more translucent character of both egg and larva, and by the first pair of prolegs being quite obsolete, in which character it resembles the *Anomis exacta* [*texana*] that affects cotton in Texas. Aletia larvæ that had been fed on cotton, when placed upon the Urena, refused to feed upon it, and finally perished.

"We recently took occasion to carefully examine the Malvaceous plants in the herbarium of the Department of Agriculture with some quite interesting results, although a herbarium is naturally the least favorable place one can choose for an entomological investigation of this character, as plants that are least injured by insects are most apt to be collected, and the mode of preserving the plants still further reduces the chances of finding traces of Aletia, because only one side of the leaf is available for examination. How small this chance is may be illustrated by the fact that on the specimens of Gossypium in the herbarium no Aletia eggs or egg-shells could be discovered, and that only one specimen showed any trace of being injured by any insect whatever. Nevertheless a number of eggs or fragments of such—some of them from their structure very closely related to Aletia—were found on the following plants: *Malvastrum spicatum*, from Florida and Nicaragua; *Urena ribesia* (which is considered a form of *U. lobata*), from Southern Florida; *Pavonia typhaleoides*, from Cuba; *Sida glomerata*, from Cuba.

"One object of this examination was to discover, if possible, the particular Malvaceous plant upon which Aletia feeds in the States north of the cotton belt, but this proved to be an almost complete failure, because the herbarium contained only six specimens of such plants from the more northern States, not counting sixteen specimens cultivated in the agricultural grounds at Washington. However, on a specimen of *Sida spinosa*, from York County, Pennsylvania, an egg was found which has every appearance of that of Aletia.

"We would earnestly call upon entomologists who may read these pages to aid us in obtaining evidence of the food-plant of the insect in the more northern States by an examination of the plants indicated by an asterisk in the following list, as it is upon such that the insect will probably be found at some future time, but only late in the season:

LOCALITIES FOR MALVACEOUS PLANTS FROM GRAY'S FLORA.

Althæa officinalis L.—Salt marshes coast of New England and New York. (Nat. from Eu.)

Malva rotundifolia L.—Waysides and cultivated grounds, common. (Nat. from Eu.)

sylvestris L.—Waysides. (Adv. from Eu.)

moschata L.—Has escaped from gardens to waysides. (Adv. from Eu.)

alcea L.—Has escaped from gardens in Chester County, Pennsylvania. (Adv. from Eu.)

Callirrhoë triangulata Gray.—Dry prairies, Wisconsin, Illinois and southward.

alcæoides Gray.—Barren oak lands, Southern Kentucky and Tennessee.

Napæa dioica L.—Limestone valleys, Pennsylvania and southward to the valley of Virginia, west to Ohio and Illinois, rare.

**Malvastrum angustum* Gray.—Rock Island in the Mississippi, Illinois.

* *coccineum* Gray.—Abounds on the plains from Iowa and Minnesota westward.

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**Sida napæa* Cav.—Rocky river banks, Pennsylvania, York County, Kanawha County, Virginia. (Cultivated in old gardens.)

elliottii T. & G.—Sandy soil, Southern Virginia and southward.

* *spinosa* L.—Waste places, common southward.

Abutilon avicennæ Gærtn.—Waste places, escaped from gardens. (Adv. from India.)

Modiola multifida Mœnch.—Low grounds, Virginia and southward.

Kosteletzkya virginica Presl.—Marshes on the coast, New York to Virginia and southward.

Hibiscus moscheutos L.—Brackish marshes along the coast, sometimes extending up rivers far beyond the influence of salt water (as above Harrisburg, Penna.), also Onondaga Lake, New York, and westward, usually within the influence of salt springs.

grandiflorus Michx.—Illinois and southward.

militaris Cav.—River banks, Pennnsylvania to Illinois and southward.

trionum L.—Escaped from gardens or grounds. (Adv. from Eu.)

syriacus L.—Escaped from gardens or grounds. (Adv. from Eu.)

NOTE 16 (p. 17).—We append a description of the larva of *Aspila virescens:*

Smooth, soft, translucent, with the normal complement of 16 legs. Color either green or lilaceous. Finely speckled, with pale yellowish spots (appearing under the lens as fleshy elevations), arranged in a somewhat longitudinal manner, and forming along the stigmatal region a tolerably well marked band; the stigmata, which are in the upper portion of this band, being black, with a carneous center and white annulation. Piliferous spots in normal position, very small, dark, with a paler annulation, the hairs fine and translucent. The two posterior joints somewhat squarely cut off. Head, thoracic legs, and cervical shield polished and slightly more yellow than body.

Full grown in July; imago issuing in August of same year.

NOTE 17 (p. 18).—Both in 1878 and 1879 Mr. Schwarz traveled throughout the southern portion of the cotton belt and visited the Bahamas, one of his special instructions being to learn, if possible, something definite as to the winter quarters of the moth. The gist of his results is given in a report published in Appendix I in the Report upon Cotton Insects, Department of Agriculture, 1879, pp. 347–349, while he also furnished Professor Comstock (*ibid.*, pp. 349, 350) with a fair summary of the conclusions that we had then come to both from his observations, our own, and those of others in the investigation then being pursued.

NOTE 18 (p. 18).—The *Platyhypena scabra* (Fabr.) of Grote's List. Its larva is grass-green in color, with a medio-dorsal and sub-dorsal lines of a darker green, the latter bordered below by a whitish line. It is cylindrical and with but three pairs of abdominal prolegs. It feeds on clover, and also on *Robinia*. The chrysalis is formed in some sheltered situation and surrounded with white silken threads; is dark and slender like that of Aletia, but the tip is armed with two strong, slightly diverging spines. In Missouri this chrysalis may be found under bark during winter, and it doubtless hibernates in both chrysalis and imago state in the South. (See chapter XV.)

NOTE 19 (p. 19).—Our notes show that larvæ of this species (*Phoberia atomaris* Hüb.) were found at Saint Louis, Mo., May 13, 1873, on oak and under chips. Most of these had entered the ground by the 29th and had transformed to pupæ June 18. Larvæ of the same species were also found at Fortress Monroe, Va., July 19, 1882, near the base of a live-oak.

NOTE 20 (p. 20).—It was our privilege to follow the reading of this paper with some remarks expressing our general appreciation of it, but urging at the same time some qualifications of the theory, and the belief that the insect hibernated in the more southern portion of the belt. These remarks seem to have had some weight, for in the printed copy of the paper in the Proceedings of the Association a qualifying

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clause (not in the paper as read or as printed at the time in the New York *Tribune*) is added, admitting the possibility of hibernation in Florida and southern Texas. Mr. Grote based his views on an experience had in what is known as the central cotton belt of Georgia and Alabama. The exact northern or southern limits of this belt are not stated, but it includes most of the canebrake region of the latter State, and extends south of what, in a broader way, we have defined as the southern or hibernating portion of the whole cotton belt. The arguments against the theory of annual immigration are therefore based on experience gained, in great part, in the same latitude and regions referred to by Mr. Grote. In 1878, Mr. Grote was connected with the Department of Agriculture, and in the work allotted to him we directed him to pay particular attention to this question of hibernation, and it is due him to state that his investigations in southern Georgia, according to his report submitted, led him to admit the possibility of the moths hibernating there, though as late as January, 1879, he was reported as having confirmed "his theory" that "the fly comes from the West Indies with the south winds every year." (*Popular Science Monthly*, vol. xiv, p. 406.)

NOTE 21 (p. 20).—A rough division of the cotton belt into a northern and southern portion was made in the Introduction to the first edition of this work, and we reproduce it here as a means of defining what we mean by the southern portion of the belt:

Some similar classification of the cotton belt will also greatly aid in the treatment of this Cotton Worm question, and as a temporary classification, to be elaborated in future, I have divided said belt into, first, the southern or permanent portion, where the first worms annually appear and the moths in all probability hibernate; second, the northern or temporary portion, in which the insect does not hibernate, but into which it spreads, either by gradual dispersion or by more sudden migration, from the permanent portion. The dividing line between these two portions must needs be difficult to define, because there is an uncertain region that may, according to season or circumstance, belong to either, and also because of the limited observations that have yet been made. Taking the early appearance of the worms as a basis, the southern portion may be thus roughly defined: Beginning with Texas, it includes the region south of the Galveston, Harrisburg and San Antonio Railroad, excluding perhaps the extreme western portion, but extending somewhat farther north along the river bottoms. In Louisiana and Mississippi it includes the valley of the Mississippi River and its tributaries, with uncertain northern limits. In Alabama it is represented by the limestone cotton belt south of Montgomery, though probably extending farther north to the east of that point. In Georgia it does not extend north of Albany on the west, but doubtless includes the sea islands along the coast, as also those of South Carolina, though at the present time cotton cultivation is limited to Saint Catharine's Island. In Florida it includes all parts where cotton is grown.

NOTE 22 (p. 37).—This claim of Professor Stelle's is later referred to in Chapter XIV, and more fully discussed in Note 57, to which the reader is referred.

NOTE 23 (p. 56).—These organs in *Leucarctia acrea* were figured and again described in *Papilio*, vol. iii, pp. 41, 42 (Febr., 1883), by Mr. R. H. Stretch, of California, and his query as to whether they had been noticed at the East brought forth notes from A. R. Grote, of New York, and C. M. Weed, of Lansing, Mich. (*Papilio*, iii, p. 84, Apr., 1883). The latter stated that he had found similar organs in the male of *Pyrrharctia isabella*.

NOTE 24 (p. 85).—Our remarks on this subject were as follows:

"The worm in my estimation is worse in wet weather than in dry, not so much because such weather is more favorable to its development, as because it prevents the numerous enemies from so effectually performing their accustomed task. The ubiquitous ant, ever ready to pounce upon the young worm when it is helpless, as at the time of hatching or of molting, and the many flying wasps, ichneumons and other insects that constantly search the leaves for this soft prey, are hindered in their predaceous work; while the worm, relieved of these watchful checks to its increase, develops apace. It is on the same grounds that I would explain the fact so generally noted, that the worm first appears in particular parts of a field. Such spots are generally the low and moist spots where the cotton grows most luxuriantly, and where ants least abound. They represent the spots of least molestation to the young worm." * * * (Abstract of an address before the Mobile Cotton Exchange, and published in *Mobile Register*, July 9, 1879, and *Colorado* (Tex.) *Citizen*, of July 17, 1879.)

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NOTE 25 (p. 87).—An interesting instance of the appetite of swine for Cotton Worms is told by a writer in the *Shelby* (Ala.) *Guide*. Two pigs, nearly dead with cholera, were turned into a field of cotton to graze. The field was overrun with worms, and the pigs fed exclusively upon them, recovering from their cholera and growing fat on the diet. Their presence induced another "gang" of pigs to enter the field, and it was surprising to see with what activity and persistence they hunted the worms. The half-starved dogs of the poor freedmen and also their cats are also reported to feed upon the worms.

NOTE 26 (p. 88).—In the Report upon Cotton Insects, Department of Agriculture, 1879, a tolerably complete list of Southern birds is given (pp. 159–162), those nesting in the South being especially designated. This list was compiled by Mr. Robert Ridgway, of the Smithsonian Institution.

NOTE 27 (p. 89).—It is a question as to how far the English Sparrow will be able to hold its own in the extreme southern portions of the country. We find, upon correspondence with the members of the American Ornithologists' Union, and especially with members on the special committee on migrations, that very little seems to be known to ornithologists as to the exact distribution of this bird in the South and West. From other sources and from our own correspondents it has obviously extended all over the South and is now even found on the Pacific coast. But it is also equally obvious that in the hotter portions of the country it is confined to towns and villages, and has not become in any way an important factor in the suppression of the Cotton Worm.

NOTE 28 (p. 89).—Having turned these spiders over to Dr. George Marx, with a request that he make a brief report upon them, he has kindly submitted the following notes with the accompanying figures:

The following list of spiders which are found inhabiting the cotton plant and feeding on the larva of the cotton moth Aletia, certainly does not comprise the full number of those spiders which, by destroying insects noxious to agriculture, deserve particular mention and description. But although the number of the present list is small and insufficient, the mentioning of these few beneficial spiders seems to me justified by the fact that it is the first attempt to draw the large and interesting order of Araneæ out of an undeserved and superstitious interdict into a more friendly relation to us. The spiders which have been observed to devour the larvæ of Aletia belong to six different families, and were the observations more complete would probably comprise all the families of the order.

EPEIROIDÆ. *Epeira stellata* H. (Pl. LXIII, Fig. 1).
Tetragnatha extensa W. (Pl. LXIV, Fig. 1, ♂ and ♀).
Tetragnatha laboriosa H.
Argiope fasciata (H.) (Pl. LXIII, Fig. 2).
THERIDIOIDÆ. *Theridula sphærula* (H.) (Pl. LXIII, Fig. 3).
Theridula quadripunctata Keyserling.
Linyphia communis H. (Pl. LXIII, Fig. 4).
Euryopis funebris (H.).
Teutana triangulosa (Keyserling).
Mimetus interfector H.
THOMISOIDÆ. *Misumena americana* Keyserling.
Misumena georgiana Keyserling.
Xysticus quadrilineatus Keyserling.
DRASSOIDÆ. *Cheiracanthium piscatorium* (H.).
ATTOIDÆ. *Attus fasciolatus* H.
Attus parvus H.
Attus cardinalis H.
OXYOPOIDÆ. *Oxyopes viridans* H. (Pl. LXIV, Fig. 2).

The mode of capturing their victims differs with the different families, but observations in this connection are very limited, though it may be stated, with considerable certainty, that the members of the Thomisoid, Drassoid and Attoid families simply jump suddenly upon the larvæ, killing them instantly by biting them to death; but the way in which the smallest and most frail of all the spiders enumerated here, the *Theridula sphærula*, captures her prey, shows so much intelligence and skill that it deserves a more full description.

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Too small in body to follow the habits of the other spiders with the slightest chances of success, nature has gifted this little heroine with a highly developed intellect by which she is enabled to come victorious out of the so uneven fight, for the larva is often twenty to thirty fold larger and heavier.

Let us look upon a larva, about half an inch long, feeding, unsuspecting the approaching danger, on the succulent leaf of the cotton plant. Suddenly we see a small black dot not much larger than the head of a pin lowering itself from a leaf above to that on which our larva feeds. This little dot is the Theridula, and, alighting on the leaf, she runs busily backward and forward about the sluggish larva, always avoiding to touch and disturb the larva, often climbing on a thread from one side to the other side, thus surrounding the victim with a nearly invisible system of threads, tireless, adding strength to it, testing here, with all her force, the durability of one cord, adding there another loop to a weak point. After an hour or more she has finished her work, and suddenly disappears to the underside of the leaf above. Now the larva becomes restless, it throws its head angrily about, its whole body jerks wildly, it endeavors to walk away, but in vain; it is held by invisible powers; nay, it is lifted up from the leaf and gradually and noiselessly is hoisted to the underside of the leaf above. It is wonderful what strength and what amount of mechanical ingenuity are here displayed. [Of the mechanism of this hoisting an often twenty times heavier weight by the spider we know little, as the threads are very thin and the spider always at the underside of a narrow projection, a crevice of a fence rail or stone, or the underside of a leaf, and being very shy, immediately interrupts her work at the slightest disturbance. According to my notes it took a Theridula one hundred minutes to lift a larva, over half an inch in length, 6½ inches to the underside of the plate of my working table.]

Having her prey, which has become exhausted and motionless by its fruitless endeavors to free itself, securely fastened to a projecting vein of the leaf, our little heroine now throws out by her hind feet a mass of threads which she fastens over the larva at the same time. Slowly and at long intervals does the larva move in its ties while the little spider runs busily about it, fastening it with more ropes to the leaf; this takes another hour, and now she cautiously approaches the larva, and after repeated trials she has selected the right spot, generally at the second or third segment, into which she introduces her poisonous fangs. Hours afterward we can see the victress motionless in the same position, sipping the sweet juice from the body of her victim.

The following facts concerning one of the commoner spiders (*Oxyopes viridans*) were published by Mr. Hubbard in the *American Entomologist*, vol. iii, p. 250:

August 28, 1880.—In the field to-day I observed a spider, *Oxyopes viridans*, eating a Tachinid (?) fly. These large green spiders are quite common. I am inclined to think they do not attack the caterpillar. I watched one resting upon the same leaf with a worm, to which the spider paid no attention. During the entire morning the spider remained upon the same leaf, while the caterpillar wandered to the next leaf, and fed in plain sight of the spider unmolested. Another specimen of the same spider ran over a leaf, on the underside of which a caterpillar was feeding. The caterpillar jerked and shook the leaf, but the spider paid no attention to it.

September 3.—This morning I could not find a caterpillar in the "Simpson cotton," excepting one just hatched. I saw the green *Oxyopes* feeding upon a bee, *Anthophora* or *Megachile*, or some bee of medium size. (I did not succeed in securing it.) There are many burrows of a *Cicindela* larva (probably *C. punctulata*, which is abundant in the cotton fields). They (the larvæ) capture ants chiefly.

NOTE 29 (p. 102).—TRICHOGRAMMA PRETIOSA Riley (*Can. Ent.*, vol. xi, p. 161.)—Length about 0.3mm, yellow, the eyes red, the wings hyaline. Head wider than the thorax; antennæ 5 jointed, joints 3 and 4 in the ♀ forming an ovate mass, and together shorter than joint 2; joint 5 large, thickened, and very obliquely truncate; in the ♂ joints 3, 4, and 5 form a more or less distinct elongate club, beset with long bristles. Hairs of the wings arranged in about fifteen lines. Abdomen not so wide as the thorax, but as long as the head and thorax together; in the ♀ the sides subparallel and the apical joint suddenly narrowed to a point.

Differs from *Trichogramma minuta* Riley (Third Rep. Ins. Mo., p. 158, fig. 72, ♀) in its smaller size and uniform pale yellow color, and also in the form of the third and fourth joints of the antennæ.

NOTE 29*a* (p. 104).—This species, although so much resembling the Trichogramma egg parasite, belongs to the family Proctotrupidæ, subfamily Mymarinæ. We have erected for it, provisionally, the MS. genus *Metamymar*, and have given it the specific name of *aleurodis*.

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NOTE 30 (p. 104).—APANTELES ALETIÆ Riley.—Length 2mm, ♂ ♀. Black; palpi white; labrum, mandibles, and basal joint of antennæ piceo-testaceous, the flagellum sometimes piceous. Legs light red, the posterior tibiæ whitish on the basal half; tips of posterior tibiæ, the posterior coxæ and tarsi, black or blackish; the posterior femora sometimes dusky. Abdomen testaceous beneath, except along the median line and on the apical third; the edges of the first joint testaceous. Wings hyaline, the tegulæ, veins, and *stigma white*. Mesoscutum closely punctured, opaque; scutellum sparsely punctured; metathorax obliquely truncate, its posterior face with a median subtrapezoidal or pentagonal area. Abdomen narrow, basal joint as long as one-half of the remainder, rugose, its posterior border excavated in the middle, remaining joints not sculptured and not highly polished. Ovipositor not exserted. Radial vein arising slightly beyond middle of stigma and forming a curve with the basal vein of the areolet. This species resembles *A. hyalinus* Cress., described from Cuba, but differs in the coloration of the legs and in the ovipositor not being thickened at the tip.

Larva.—4mm in length. A smooth, memberless grub, narrowing towards the head and thickest near the posterior end; the head nearly as large as the first joint, the sutures between the joints rather indistinct. The mouth-parts minute, similar to those of other hymenopterous parasites. The sixth, seventh, eighth, and ninth joints behind the head provided with a pair of prominent lateral tubercles; pairs of slighter tubercles on the fifth and tenth joints. Color white, or tinged with green or yellow. —[*Trans. Acad. Sci. St. Louis*, iv, p. 306; Sep., author's ed., pp. 3 and 11.

NOTE 31 (p. 105).—The only specimen of the Chalcid bred from *Apanteles aletiæ* is mounted in balsam, and by accidental pressure has separated into pieces. From the fragments of the antennæ and from the wings it is quite evident that it is the male of some species of *Eupelmus*.

NOTE 32 (p. 105).—The following revised description by Mr. Howard of Comstock's Euplectrus is from Bulletin 5, Bureau of Entomology, United States Department of Agriculture:

EUPLECTRUS COMSTOCKII Howard. *Male.*—Length, 1.98mm; wing expanse, 4.3mm; greatest width of fore wing 0.8mm. Face triangular, narrowing sharply below eyes, smooth and glistening, with a very few punctures; antennal scape slender, not widened. Pronotum very rugose, except at posterior border; mesoscutum somewhat transversely rugose, with a strongly-marked median longitudinal carina; mesoscutellum smooth; metathoracic carina very pronounced and dividing posteriorly; metatibial spine nearly as long as first two tarsal joints. Abdomen broadening from base and subtruncate at tip. General color shining black with long stiff whitish hairs scattered over thorax; labrum honey-yellow; antennal scape light honey-yellow, flagellum gradually darker, club quite dark at tip; all legs honey-yellow; abdomen with a dorsal yellow spot entirely bounded with black and of an irregular pyramidal shape, the base of the pyramid towards tip of abdomen; venter yellow-brown along median line.

Female.—Slightly larger; abdomen more nearly ovate.

NOTE 33 (p. 106).—We give here a description of this secondary parasite, drawn up by Mr. Howard:

ELACHISTUS EUPLECTRI Howard (new species). *Female.*—Length of body 1.8mm. Expanse of wings, 3.0mm. Greatest width of fore wing 0.53mm. Parapsidal sutures almost continuous with scapular sutures; mesoscutellum with a slight notch at its anterior border and a clean median furrow. Occiput and petiole finely but densely punctured; face and mesoscutum finely shagreened; mesoscutellum smooth, with two longitudinal furrows of deeply impressed dots. Abdomen oval acuminate, with the large first joint smooth and shining, slightly shagreened at its posterior border; the succeeding joints all slightly shagreened, and each with a transverse row of white hairs. Stigmal vein very short and globular; post marginal twice the length of stigmal. Color, dark metallic green; scape of antennæ and all legs white or faintly yellowish; wing veins dark brown.

Male.—Slightly smaller than ♀; abdomen ovate; parapsidal sutures not continuous with scapular, but meeting so as to give the mesoscutum a pointed appearance. Color: head and thorax with a strong coppery luster, bluish beneath; abdomen bright metallic blue, not shagreened; antennal scape white, metallic blue at tip. In other

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respects similar to ♀. Described from 1 ♂ 5 ♀ specimens, bred from *Euplectrus comstockii* at Selma, Ala.

This species seems to belong to Thomson's third section of the genus *Elachistus*.

NOTE 34 (p. 107).—Except in lacking the two bristles at the apex of the third segment of the abdomen which are prominent in *sarraceniæ* (type), and in other species, the specimen differs in no respect from those found to infest the Rocky Mountain Locust and *Caloptenus differentialis* (Locust Plague, &c., pp. 135, 136; and First Ann. Rep. U. S. Ent. Comm., p. 324). Although in the works here cited *sarraceniæ* is considered a variety of the common European *S. carnaria* it seems best to maintain it as a distinct species in accordance with the characters given by Mr. R. H. Meade, who, in his "Monograph upon the British species of Sarcophaga or Flesh-fly" (Ent. Mo. Mag., vol. xii, p. 216 ff., Febr.-May, 1876), separates the species into two principal divisions, according as the tip of the abdomen is red or is black or gray. In a note published in Baron Osten Sacken's Catalogue of the described Diptera of N. A., 2d ed., p. 257, Mr. Meade says: "There is no specimen in your collection, however, exactly like the true *S. carnaria* so common in Europe. There are some striking points of difference between the *Sarcophagæ* of America and Europe generally, the chief of which is that in the former species with one or both anal segments red or yellow predominate, while among the latter, those with the anal segments black or gray are more numerous than those with the red."

The following additional specific characters may be added: Thorax with four bristles behind the suture in the two dorsal rows, the two anterior bristles small, the two posterior strong; in front of the suture are two small bristles alternating with two of slightly larger size. There are no minute spines on the second longitudinal vein similar to those on the fourth. The posterior tibiæ of the ♂ are loosely bearded on the inner side with long soft hairs. The second abdominal joint is not armed with strong central spines, and the spines at the apex of the third joint are short and weak.

NOTE 35 (p. 109).—TACHINA ALETIÆ Riley (*Can. Ent.*, vol. xi, p. 162).—Length 8^{mm}. Black; head golden, facial depression silvery, space between the eyes and the frontal stripe about equal to the breadth of the stripe, bristles of the head black, the pubescence behind and beneath the eyes white; antennæ blackish, palpi testaceous. Eyes at a moderate distance apart, thinly pubescent; front moderately prominent; third joint of the antennæ three or four times the length of the second joint. Thorax and the second and following abdominal joints more or less ashy, the thorax with four or five longitudinal black stripes. Wings subhyaline. Legs black, with a piceous tinge; tarsal cushions yellowish. Scutellum and the sides of the first, second, and third abdominal joints sometimes tinged with reddish-brown. No strong bristles on the first and second abdominal joints above.

NOTE 36 (p. 109). TACHINA FRATERNA Comstock (Annual Report of Commissioner of Agriculture, 1879, p. 303).—Color: General effect nearly black; head, face, and facial depression silvery white, inclining slightly to golden on occiput; antennæ, first and third joints black, second joint testaceous; palpi testaceous; pubescence behind the head blackish; thorax, second and following abdominal joints ashy; thorax with two plain longitudinal black stripes and two indistinct; first abdominal joint black above, ashy beneath; femora piceous; tibiæ and tarsi nearly black. Eyes finely pubescent. In other respects resembling *T. aletiæ* Riley. Described from two specimens.

NOTE 37 (p. 110).—The Tachinid *larva* differs from that of *Sarcophaga* in the following characters: It is of a paler whitish color, the skin being softer or less chitinized; the body is less narrowed anteriorly; the prothoracic spiracles are less apparent; a pair of spiracles are present on the posterior border of the fourth joint behind the head, which are not discoverable in *Sarcophaga;* the joints are not conspicuously wrinkled transversely and there are no lateral prominences, the anterior portion of each joint being prominent and roughened with minute points; the spiracular cavity at the end of the body is more shallow, the spiracles being exposed upon the obliquely truncated area, and there are no anal prolegs. The Tachinid *puparium* may be readily

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distinguished from that of *Sarcophaga* by the obsolescence (or in some species entire absence) of the prothoracic spiracles so prominent in *Sarcophaga*, and the absence of a cavity for the anal spiracles, both ends of the body being quite uniformly rounded.

Barthélemy has described the larva of *Senometopia atropivora* (*Ann. Sc. Nat.*, 4e sér., vii, p. 115), while Laboulbène has described both larva and pupa of *Tachina villica* (*Ann. Soc. Ent. Fr.*, 1861, p. 231, pl. 7); but as these descriptions are not readily accessible to the American reader, I reproduce from the Trans. Ac. Sc. St. Louis, vol. iii, p. 238–239 my description of the larva and pupa of *Sarcophaga sarraceniæ*, and add for comparison that of *Belvoisia bifasciata* (Fab.), one of our largest and most beautiful species, parasitic on *Citheronia regalis* and various species of *Dryocampa*.

SARCOPHAGA SARRACENIÆ. *Larva.*—0.30–0.85 inch long. Body composed of but 11 visible joints exclusive of the head; microscopically and transversely shagreened; transversely wrinkled, the hind wrinkle on each joint more particularly prominent laterally. Head extremely small, or one-fourth as large as joint 1, showing a division into two maxillary lobes at the tip and a larger labial lobe beneath, with a small bunch of setous fibres issuing from it; the black retractile jaws, of the ordinary form, issuing between these lobes, and the antennæ showing in two small rufous projections above the maxillary lobes, sparsely armed anteriorly with minute conical, sharp-pointed spines decurved in front, directed backward beneath. Prothoracic spiracle pale rufous, retractile, sponge-like, studded with numerous lobules, divided at the end into a variable number of branches (6 being usually apparent, never more than 8), which in their turn ramify into lobules. Anal stigmatic cavity quite deep; the fleshy prominences on the carina surrounding it, sub-obsolete; the stigmata but slightly excavated below, the border brown, inclosing three brown openings, the lower ends of which reach to a circular clear space in the corneous and pale rufous peritreme. Anal prolegs quite small, with the longitudinal anal slit between, and a corneous plate in front of them.

Puparium.—0.25–0.50 inch long; neither smooth nor highly polished, and varying from yellowish-brown to deep brown-black in color. Insections more or less distinctly traceable. Head and prothoracic joint retracted; the prothoracic spiracles protruding and forming two small ears about as long as joint 2; the mass of lobules hardened and rufous. Joints 2 and 3 constricted and flattened; 4 suddenly bulging. End of body squarely docked by spiracular cavity, the rim of which forms quite a ridge.

BELVOISIA BIFASCIATA. *Larva.*—Length 15mm. White, the skin soft; body cylindrical, tapering on the anterior joints towards the head, the apex obliquely truncated. Head small, furnished with two stout black hooks, situated under two crescentic elevations at a moderate distance apart; when viewed from in front the head obscurely bilobed, near the center of each lobe two chitinous points, one situated above the other. No prothoracic spiracles apparent, a distinct circular spiracle on the posterior border of the fourth joint behind the head, and situated slightly above the median line. The anterior border of each joint slightly prominent and, except on the dorsal side of the apical joints, roughened with minute points, the posterior border of the apical joints similarly roughened. Joints 4–11 with a distinct transverse median depression on the ventral side, the depression deepest on the intermediate joints, the portion behind this depression on the joint 11 forming a prominent transverse tubercle beneath the truncation, upon which the anal spiracles are situated. Anal spiracles black, each with the slit-like openings, and a circular spot in a clear space beneath them.

In Westwood's Introduction, vol. ii, fig. 131, is copied from Bouché, a figure of the larva of *Tachina concinnata* of similar form to that of *Belvoisia;* but the peculiar "prothoracic spiracle" figured in connection is not apparent in the larva before me. In the normal form of the Tachinid *puparium* the anterior pair of spiracular openings are even with the general surface of the puparium, so as to be discoverable with difficulty. The true spiracles are internal, and may be found opposite these perforations on the membrane which lines the puparium after the fly has escaped. The puparium is reddish-brown, the anal spiracles and the anus black; the joint of the body not distinct;

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the anal spiracles distinctly upon the surface of the subtruncated posterior end, not situated in a cavity as in *Sarcophaga;* just beneath these spiracles is a slight transverse elevation.

The puparium of *Belvoisia bifasciata* differs somewhat from the ordinary form. It is black, roughened, increases in width posteriorly, has the anal spiracles drawn far forward upon the back, and each represented by three swollen tubercles, and the space between them and the tip of the puparium is very irregular and has a conspicuous transverse depression.

NOTE 38 (p. 111).—*Cryptus conquisitor*, Say (*Bost. Jour.*, i, 232), of which, as Walsh (*Canadian Entomologist*, ii, 12) pointed out, *Cryptus pleurivinctus*, Say (l. c., 235), is a synonym. By some oversight *pleurivinctus* stands as a synonym under *annulicornis*, Cress., instead of *conquisitor*, in Mr. Cresson's List of the North American *Pimplariæ* (*Trans. Am. Ent. Soc.*, iii, 170).

NOTE 39 (p. 114).—The name *Cryptus extrematis* Cress. should yield to *C. samiæ* Pack., because two species (one of which is *nuncius*) were combined under it in the original description.

NOTE 40 (p. 115).—We gave the following description of the larva and pupa of *Chalcis ovata* in the first edition of this report:

The *larva* is a slender legless maggot, 7mm in length. The body tapers at each end, particularly behind, and has a conspicuous lateral ridge. The head is similar to that of the *Pimpla* larva described further on, but the mandibles are nearly concealed, being covered by the other mouth parts. The first three joints of the body are separated by deeper constrictions than the succeeding joints, and the lateral tubercles on joints 4–10 have a smaller but distinct tubercle behind them. The spiracles in the alcoholic specimen are indistinct, owing to their agreeing with the skin in color; but their position is apparent upon the anterior border of the second, third, fourth, and several of the posterior joints. Length 7mm.

The *pupa* is short and robust; pale at first but becoming brown, the head and thorax anteriorly darker. It has two prominent tubercles between the eyes just above the insertion of the antennæ, and above each of these a slight ridge extending as high as the lower ocellus, which is situated on a slight prominence within the fork of an impressed line on the vertex. Only five distinct joints in the antennæ between the scape.

In addition to *Desmia maculalis*, and the two species of *Apatura* mentioned in the text, we have bred this parasite from *Thyridopteryx ephemeræformis* (Haw.), *Cacœcia rosaceana* (Harr.), *Gelechia gallæ solidaginis*, Riley, and *Botis alnialis* Riley MS. (See Bulletin 5, United States Department of Agriculture, Division of Entomology, p. 8.) The species is very variable in size, and we have specimens as small as 3mm in length while others measure as much as 6mm.

NOTE 41 (p. 115).—This species (*Tetrastichus esurus*, Riley) was treated in the first edition under the generic name *Cirrospilus*, and in the original description (*Canadian Entomologist*, xi, 162), it was also placed in that genus, but only provisionally, and we there called attention to its close relationship with *Tetrastichus*. Since receiving more abundant and better material, and after a closer study, we have decided that it should be placed in the latter genus. We reproduce the original description:

Length 1.5mm. Dull black; knees, tibiæ, and tarsi yellowish; the posterior tibiæ sometimes dusky. Eyes with scattered short bristles. Antennæ of the ♂ 9-jointed, with the joints of the flagellum subequal and beset with bristles, the ninth joint small. Antennæ of the ♀ 8-jointed, the fourth and fifth shorter than the second and third, the three apical joints forming a club. Thorax above microscopically punctate; parapsides distinct and elevated; scutellum with a longitudinal impressed line on each side. Wings hyaline, pubescent, but the cilia short; base of ulna uneven; radius not developed. Abdomen short and sessile; ovate.—(*Can. Ent.*, xi, p. 162.)

NOTE 42 (p. 115). *Hexaplasta zigzag*.—We reproduce the original description of this species:

Average length 1.6mm. Body uniformly polished black. Legs, palpi and antennæ reddish in the female; coxæ, femora, and antennæ toward tip infuscate in the male. Peduncled joints of antennæ with a few minute spines around the crown, and longi-

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tudinally striate. Base of thorax and of abdomen with pale pubescent hairs. Wings hyaline, sparsely beset with minute spines which increase radially and form a fringe around the posterior half; the veins of front wings forming a sprawling W, with partial cross veins proceeding from the lower angles, the basal cross vein longest; the longitudinal veins with a few prominent spines. Abdomen, ♀, showing but 4 joints, the terminal three short and hardly distinguishable ventrally.—(*Am. Ent.*, iii, p. 52.)

In almost every larger group of organisms there are doubtful forms which it is difficult to classify, and between the three families of Chalcididæ, Proctotrupidæ and Cynipidæ, of small hymenopterous insects, it is difficult, if not impossible, to give definitions which permit the ready placing of some of the more osculant forms. Nor can habit be any more safely relied on; for while the first two families are essentially parasitic and the last gall-making; yet, according to present definitions, species of the first are exceptionally gall-making, and species of the last, as in the present case, exceptionally parasitic.

NOTE 43 (p. 117).—The following is Mr. Hubbard's communication, together with our editorial note as it originally appeared:

Phora aletiæ not a true parasite.—In examining my breeding jars and boxes, I invariably find a species of *Phora* present in them, whenever they contain any dead animal matter. This is, so far as I can make out, the *Phora aletiæ* which Prof. Comstock considers one of the parasites of Aletia. Mr. Trelease gives his experience with this fly exactly as I should myself, from my own observations. He does not consider it a true parasite, but yields the point to Prof. Comstock. Evidence is daily accumulating in my notes of the purely scavenger habits of the *Phora*. To-day I watched them pass through the meshes of fine muslin gauze, covering my breeding jars, in which moths have died, or pupæ been killed by dampness and mold. They (the flies) gather about moldy food and excrement of larvæ, but do not deposit eggs unless they find dead moths, larvæ, or pupæ, and moisture. The flies are very persistent in pushing through crevices, and I watched with interest the gravid ♀ ♀ try to squeeze through the gauze. Sooner or later, after many trials, a ♀ finds a mesh that is loose, and gets through. I see that they have often widened the meshes and pass and repass through.—(H. G. Hubbard, Centreville, Leon Co., Florida, Aug. 6.)

[This *Phora* was obtained by us on several occasions from Aletia chrysalids, in 1879, and quite commonly by Mr. Schwarz, but we never considered it truly parasitic, and doubt whether it ever is strictly so.—ED.]—(*American Entomologist*, vol. iii, p. 228.)

NOTE 44 (p. 129).—In advocating the destruction of the moth by lights and fires one circumstance has been generally overlooked, which, if proven to be correct, is almost fatal to the theory of the usefulness of this remedy. We refer to the experience of lepidopterists that the vast majority of the moths attracted by light are males. Our attention was called too late to this fact to verify it in the case of Aletia by actual examination in the field, as the moths we found attracted by the lights had not been preserved, but upon examining a number of Lachnosternas which had thus been collected we found them to be all males with one exception. It is evident that if only the males are attracted the effect of the remedy is reduced to almost nothing.

NOTE 45 (p. 138).—So long as such cases of poisoning are liable to occur, it will be well to widely publish the means of counteracting the poison. The antidote most highly recommended and found in practice to be effectual is hydrated sesquioxide or peroxide of iron, which may be purchased at any drug store. A few spoonfuls taken soon after a case of poisoning will counteract any evil effects. Another very simple antidote is to drink the water (or even to apply it externally) in which old, rusty nails, or other rusty iron have been washed, or in which the rust scraped from old iron has been stirred up.

NOTE 46 (p. 140).—It is the uniform experience that the non-fertilized blossoms are destroyed by wet application of poisons during the earlier hours of the forenoon or even by a rain-shower at that time. This seems to be correct, though it is difficult to arrive at a definite conclusion, as a great many blossoms are daily lost in consequence of overproduction. So far as the experiments go, the wet application during clear, hot weather in the forenoon seems to be more liable to injure the plant than in the afternoon or during cloudy weather.

NOTE 47 (p. 143).—An easy way of testing the purity of Paris green is to put about

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100 grains in an ordinary wine-glass and add thereto an ounce of liquid ammonia. In proportion as there is little or no sediment the green may be considered pure.

NOTE 48 (p. 145).—This mixture consisted of 6 pounds of the green to one barrel of flour, in addition to about 20 pounds of adhesive materials; in round numbers, therefore, of 1 pound of green to 35 pounds diluents, this proportion being generally used near Selma, Ala.

NOTE 49 (p. 162).—The following note on the use of kerosene on cotton is from Dr. Barnard's report of experiments made at Selma (Ala.), in the summer of 1883. (Bull. 3, Entomological Division, United States Department of Agriculture, p. 47):

Concerning the use of kerosene upon cotton, the following should be stated: About 10 gallons were applied, half undiluted and half in emulsion variously diluted. The undiluted petroleum destroyed about 10 per cent. of the foilage sprayed by it. The undiluted milk-kerosene emulsion ruined only about 2 per cent., and this diluted injures less and less according to the attenuation, but all treated was injured to at least a slight extent. The sprays were hardly satisfactory, as the tubing would not permit the high pressure necessary for a very fine mist, and the indications are that with the finest spray the strong kerosene and its slightly diluted preparations may possibly yet become used, in proper hands with great caution, upon the crop, but additional experimental tests are needed.

NOTE 50 (p. 165).—Mr. Willemot calls his plant *Pyrèthre du caucase* (*Pyrethrum willemoti* Duchartre), but it is more than probable that this is only a synonym of *Pyrethrum roseum*. We have drawn liberally from Willemot's paper on the subject, a translation of which may be found in the Report of the Commissioner of Patents for the year 1861, Agriculture, pp. 223–231.

NOTE 51 (p. 167).—A very good illustration of the growth of the productive industry in this country is afforded by the fact that Mr. George Laird, superintendent of the Buhach plantation, produced about 40 tons of blossoms in 1884, and employed some 250 Chinamen during 13 days in gathering the crop.

It has generally been supposed that Pyrethrum is innocuous to animals, but in this connection we quote some remarks from an address which we delivered before the Georgia State Agricultural Society, February 12, 1884:

Pyrethrum is supposed to have no effect on the higher animals, but that is a mistake, as my own recent experience is that the fumes in a closed room have a toxic influence, intensifying sleep and inducing stupor; while the experience of Prof. A. Graham Bell, with the powder copiously rubbed on to a dog, showed that the animal was made sick and was affected in the locomotive organs very much as insects are. The wonderful influence of this powder on insects has led me to believe that it might prove useful as a disinfectant against fevers and various contagious diseases by destroying the microzoa and other micro-organisms, or germs which are believed to produce such diseases. It should be tried for that purpose. It is remarkable that these two plants of all the many known species of the genus, should alone possess the insecticide property.

NOTE 52 (p. 174).—It is evident that Pyrethrum can be produced as cheaply in California, with the Chinese labor, as in any other part of the country; yet the reduction in price has not been as great with the increase of production as we have been led to hope. We cannot find in any case that it has been offered for less than 50 cents per pound, when the purity is guaranteed, though a New York firm informs us that they will be able to sell as low as 30 cents in large quantities.

NOTE 53 (p. 179).—Indirectly, also, such enemies of Aletia are killed as feed on the poisoned worms, and in recently poisoned fields dead birds and larger ground beetles have been reported found, the destruction of which must doubtless be attributed to the poison. The number of such cases is, perhaps, larger than can be actually proven.

NOTE 54 (p. 184).—In order to illustrate how positively this and other plants, here enumerated, were recommended to the Commission, we give herewith, without further comment, the following letter from a correspondent in Mississippi:

Some years since, when a caterpillar was stripping the oaks in front of my yard, I observed that some which had ascended an Ailanthus tree (frequently called "the

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tree of Heaven") fell from it paralyzed, and soon died. So, when the caterpillars attempted to cross my fence, I placed in their way, at short intervals, branches of Ailanthus leaves, and killed immense numbers of them, effectually protecting my yard and garden. I have to suggest the expediency of trying this native poison, so abundant and easily accessible, on the cotton-worm. I have found the common larkspur an effective poison on insects. Would it not answer as well for the Cotton Worm?

NOTE 55 (p. 184).—The universal belief that these two species of dog fennel are never attacked by any insect is without any foundation. We found a small Longicorn borer (larva of *Mecas inornata*) boring in the stem; an unnamed species of *Baris* bores in the root, while the flower-heads are badly infested by several species of *Brachytarsus*.

NOTE 56 (p. 288).—The results of these experiments were published in Bulletin 3, Division of Entomology, United States Department of Agriculture. The machine had been perfected to a large extent without accurate field test of its practical working, and in order to learn whether any improvements could be made in its several parts, or what faults it possessed as a working machine, as soon as news came that the worms were at work around Selma, Dr. Barnard was sent down with instructions to make the proper experiments. His report, which follows, would seem to show that considerable modification in the details, especially of attachment, is necessary. Future experiments may lead to the abandonment of the attempt to spray cotton from the ground up, on account of the irregularity of the rows in the average cotton-field, and the adoption of lateral or oblique spraying from nozzles that do not drag entirely on the ground, but hang some inches above it. While the crookedness in the rows in ordinary cotton fields is an obstacle to the use of any complicated machinery, yet it is a mistake to suppose that cotton is planted so irregularly in all parts of the South. While it holds particularly true in the easily washed and hilly country, characteristic of the larger parts of the cotton-growing sections of the Carolinas, Georgia, and Alabama, it is by no means to the same extent true in the richer cotton-producing sections of the South, as in the larger part of Mississippi and Texas, and the canebrake portions of Alabama. Hence the machine in question, as illustrated in the report, will prove more satisfactory in these sections, the elastic fork giving sufficient play to accommodate the nozzles to whatever slight irregularities in width are found in well-planted fields.

The Cotton Worm machine described in the annual report for 1881–'82, and now subjected to field tests, is shown to be suited only for cotton so planted that the rows are spaced apart very equally, since it lacks adaptability to the usual great differences of interspaces between the rows. Unfortunately, nothing very closely approaching ideal straightness of rows or equality of width between them can be detected in the South, even in such fields as are said to be "planted perfectly true." In the more evenly disposed cotton, stiff fork apparatus, made light and shorter, to supply only four rows at each drive, and hung loosely upon hooks instead of eyes, without the ratchet lever elevator, and capable of being easily slid by hand to the left or right, as infringement on row crooks from time to time required, proved susceptible of use with due watchfulness; but the eight-row machine was too heavy to be thus shifted by hand, and being stiff-backed with rigid descending pipes, no eight consecutive rows could be found regular enough to be callipered for much distance by this device. The inflexibility also prevented conformability of the apparatus to inequalities of the ground, an elevation straining hard on one descending pipe, lifting the others from the ground, &c., and the light, flexile, jointed nozzle-arms, being borne upon severely by the stiff pipe system, soon became impaired, whereas they had formerly and have since worked well on the yielding stem-pipes of the adjustable machines which were tested at the time of the Atlanta exposition, as well as in these last experiments. For under-spraying, this old-fashioned, stiff, cross-pipe system is shown to be wrong, as originally foreseen, unless some power can be brought to bear to enforce a system of greater straightness and equality in planting cotton. A considerable amount of the irregularity in rows has been attributed to the "constitutional perversity and crookedness of the nigger," appearing from the bad execution of his instructions. But even if this could be corrected it is not the matter of vital importance, for the planter himself, as well as the field-hand, is guided by a natural principle which will always control and stand against any contrary theoretical or mechanical rule. According to "the strength of the ground," the size of plant it will produce, will the rows run wider or narrower in any particular "cut" or part of a "cut." This

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accounts for the diverging and meandering rows, for the many "cuts" of a plantation differing among each other in their row-widths as observed everywhere.

As to conveyances for underspraying apparatuses, it was found not desirable to use a wagon or cart of ordinary width (5 feet) in cotton only 3 feet wide or less, because of the great injury done to the plants by the wheels. Most of the cotton in the Carolinas, Georgia, Tennessee, Alabama, and Mississippi comes within these dimensions; hence a shorter special axle for the cart or wagon wheels should generally be employed in any conveyance for the apparatus. But where severely threatened by worms the ordinary wagon or cart will do less damage than the pest in any kind of cotton; and it is on this account that wagons are already used to a considerable extent for transporting poison and broadcast spraying devices in all kinds of fields. Mr. A. T. Jones, near Selma, uses four mules on his heavy spraying machine. But ordinarily the common plantation cart will be found the most suitable vehicle. This or the lumber wagon will straddle rows 4 feet apart or over without injury to the plants except in turning, and that is surprisingly small, being least with the cart. With shafts placed in the usual position the mule must travel on a row to have the two wheels straddle it properly, and this is not practical. I obviated the objection by a pair of rough shafts set to one side, one shaft coming from the center of the cart and the other standing outside of the wheel; thus the mule is held nearly in front of one wheel and midway between a pair of rows. In practice it is shown that the slight side-draft caused by this arrangement amounts to almost nothing. And it should be remembered that it is common in the North to use side shafts on sleighs, buggies, &c. The apparatus is easily pulled by one mule, which should travel preferably in front of the right wheel.

The personal labor required is such that the pumper may also drive and keep an eye on the machine behind. It is most convenient when the stirrer, pump, and barrel are placed near the left side of the cart, with the lever or pump-handle standing crosswise. The operator then only looks to the right and the left, instead of having to look backward. The mule, accustomed to working in cotton, follows between the rows as a rule without being guided, and the pumper is free to turn him at the ends. In this manner one man can use the apparatus alone without working any harder than he should. Still, it is generally preferable to have a boy attendant to assist at times, and where a larger pump with a very wide system of pipes to supply a large number of rows is engaged it will be well to have two men, to take turns at pumping in cases where a pump motor is not provided. With such labor, the adjustable under-spraying machines which I have devised and shall notice below were operated, the best hand being a mulatto who worked for 50 cents a day, which is a common price for cotton-field hands. Thus the labor cost is small, and one or two men with a machine can do much more and better spraying than a large gang does by ordinary methods.

The rapidity depends altogether on the width of the pipe-system, or number and width of rows supplied, or the size of the cotton, of the nozzle-discharges and of the pump, on the velocity or pressure applied, and on the speed of the mule. It may vary with any one of these details. I had only one pump, this very small, and could not try the effects of different sizes. There was not much diversity in the cotton and it was below medium size. At Selma, I labored under difficulties from bad workmanship, from lack of available mechanics for constructing the devices, on which account there were bad joints in the apparatuses, which leaked some, and which would loosen and at times come apart when high pressure was applied, thus causing stoppages in the work. Under the circumstances the question of time and scope could not be very satisfactorily tested; but as to the very fine small sprays for small cotton the following conclusions result from this experience:

Taking nearly average sized cotton, and the parts of the apparatus of medium capacity, an acre and a half was poisoned in one-half an hour, 24 feet wide being poisoned at a single drive, and the rows were quite short. Twice this rapidity can be attained.

The quantity of liquid and poison used also depends on the various conditions stated as determining the rapidity. The amount of liquid to the acre, as near as could be estimated under the circumstances, ranged from 10 to 40 gallons, according to the size of the spray-discharge and of the cotton. The quantity of poison is in direct proportion thereto, being one-eighth to one-half a pound of London purple, or one-fourth to four-fourths of a pound of Paris green to the acre.

The stirrer-pump device is a most perfect thing for the purpose and gave the greatest satisfaction. This contrivance is described and illustrated in the annual report for 1881–'82 (Pl. IX, pp. 159–161). The pump has heavy metallic valves, and its piston-head has no soft packing, so there is nothing about it that can get out of order. Yarn packing is used in the stuffing-box at its top. Being double acting it throws a strong and constant stream. Only one trunnion-eye need be moved, and a a single iron wedge, instead of two, is sufficient for setting it. The wedge has on its head a catch whereby it is easily pried out, and an eye by which it is chained fast

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to prevent losing it. In place of the wooden stirrer bar formerly employed I have made an iron one having a spring at the middle to clamp snugly in the eye at the bottom of the pump. This will not weaken with age or break. The cord or chain for pulling out the bar is not essential, as by having the end bung-hole of 2 inches diameter a pair of tongs or pinchers can be inserted to take hold of the end of the stirrer and extract it. The main hose or pipe has a screw union, by which it is easily separable from the pump.

The descending pipes between the rows should have flexion and torsion in their joints or segments or hangings. The ground beneath the cotton-rows is highly ridged, and the mid-furrow between each pair of rows is deep. The ground thus formed operates upon the lower parts of each descending pipe or its appurtenances, when suitably shaped, so as automatically to guide the pipe and its nozzles between the rows, and to follow any crooks therein even when the conveyance is not driven in conformity with such irregularities. This automatical adjusting is allowed to a large extent, even when the top of the descending pipe is firmly or non-adjustably attached, provided that the descending pipe be flexile in some part of its course. This was shown in the earlier flexile forked machines which were tested for this Department near the Atlanta exposition. For the object in question the descending pipe may be flexile throughout, but it is more commonly preferable to construct this pipe of stiff segments having one or two flexile joints, or very short hose segments; one at its top, and another at about two-thirds or one-half of the way downward therefrom. It is also generally best to make these flexile segments or joints of three-ply or two-ply hose, and only of such length as to allow them to bend like knee-joints, and to suffer a semi-rotation or semi-torsion. This construction prevents the trailing fork or other end part from getting turned upside down, or from remaining in wrong attitude after dragging among or over the plants in turning, and it always tends to spring or throw the nozzles back to such positions that they deliver a properly-directed spray into the plants. Where torsion without bending is desired in these flexile places a rod extending through the interior may be employed somewhat as described for cross-pipes and nozzle-arms in the special report of the United States Entomological Commission that has been prepared. The arrangements and constructions referred to have been carefully tested this season to corroborate the results of previous experience. The principle involved is simple and practical in its operation, having been tested at Atlanta, and again this year at Selma, Ala.

The flexile nozzle-arms of the Y-shaped trailing forks, which were originally designed with the flexile stems worked satisfactorily thus attached; but when these fork-arms were tested on a stiffly hung pipe, the spring-rod inside soon proved too weak. The strong pendant T-forks with curved or sloping side-arms made stiff proximally, and having 3-ply hose for their distal half or two-thirds, stood severe usage by all methods, since they were made of stronger tubing and had much stouter spring-rods within. The spring-rod in each arm had its distal end soldered in a short piece of tube abutting against the stem of the nozzle. Forks of whatever construction will be guided more by the ridges if the arms extend in a somewhat upward direction before becoming horizontal at the ends beneath the plants, as the median part of the fork can then sink into the mid furrow and be guided by its sides. Probably nothing better than the pendant Y-forks and T-forks can be devised for spraying upward through the center of the plant. An additional pair of short arms or of nozzles may be used with advantage to discharge from near the median line in divergent direction upward through the tops of the plants. The simplest plan is to join these or the simple eddy chambers directly to the stem-pipe or its extension, low down. Such nozzles may be attached side by side, or in what I call a tandem gang. This is a series of short tubes coupled end to end, each bearing an eddy-chamber discharge. These may be rotated on their axes and so are adjustable to different angles. Those who prefer to underspray the top of the plant and care less for its base will find the tandem arrangement by itself the best device for that purpose for throwing from the ground, though the forks answer as well when elevated, and may also be used beneath the base.

The eddy-chamber nozzles seem the best sprayers available for applying the poison. These nozzles have been tested this season with the discharge-hole of various sizes, from one-sixty-fourth to one-eighth of an inch diameter. The smaller orifices give the finest sprays conceivable. Indeed, with high pressure, the spray vanishes into vapor and steam which does not fall, but rises to seek the clouds. From this the damp particles of poison powder must separate and fall. But with ordinary pressure too fine a spray is not attained.

With the fine strainer on the suction end of the pump, clogging materials in the water are prevented from entering the pipe system or the nozzles. Additional smaller gauze strainers were attached to the ends of the metal tubes in one set of pipes. They keep out dirt, &c., when the pipes are separated, but may not prove of importance. The proper method is to have a completely closed system, with folding joints that never need to be separated, so the whole can be folded into a small compact pack-

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age for transportation by rail or to the field. Such a system has given great satisfaction by its convenience, as well as by allowing no obstacles to enter the nozzles. In spite of the most perfect precautions clogging will occur at the outset or before high pressure is attained, chiefly from the scales of iron separating from the interior of the pipe as loosened by rusting and jarring. With the finest nozzles (one sixty-fourth inch discharge) these seem to cause no more difficulty than with a standard beveled one-sixteenth inch discharge. The nozzle faces may be removed to let out any obstacles which with low pressure are apt to clog the outlet and stop the internal rotation. But a high pressure should always be used, and when this is once up the outlet may be pricked with a pin, and it will discharge with an almost explosive force, instantly starting an inconceivably rapid internal rotation, which, while sustained with due pressure, will by its centrifugal action prevent any particle from again finding the center of rotation from which the discharge takes place. This is especially true of the smallest nozzles, having an outlet just large enough to admit the insertion of a pin. As previously set forth, the inner edge of the outlet should generally be square or sharp. In the eddy chamber a great hydraulic pressure is generated, so great that by thumb pressure the discharge cannot be stopped. The power therein accumulated under high pressure is sufficient to cut through and disintegrate any obstructing particles or fragments, except those of the hardest kind, which are so heavy as to fly off from the center by their weight and momentum when the velocity of rotation is once up or quickly starts.

The top adjustments of the descending pipes are very important. These tops may be variously hung, combined, or constructed. A knowledge of the irregularities of ordinary cotton fields, such as appear chiefly in crooks of the rows and in variations of width between them, prevents the idea of a stiff, unadjustable attachment of the tops of the pipes, which must travel between and more or less against the rows. Conformity to all inequalities of the ground, its numerous ups and downs, its dead furrows, ditches, stones, and stumps, should likewise be attained. It must also be evident that a large, stiff apparatus is difficult to haul about, as it cannot be taken entire through gates except with much labor. Of course it is possible to disjoint the parts beforehand, and then screw them together tight afterwards when the field is reached. This, however, is hardly practicable. In fact the separating and joining of stiff metal joints by field hands is a failure. Plumber's tools are necessary for this purpose. The field laborer of the South screws up the joint too tight, too loose, or in such form as to spoil the screw-threads. Again, the joints become rusted together and a vise must be engaged. The stiff system also requires that very heavy pipe be used, as the leverage on long pipe arms enables them to suffer great strain, to become broken off easily at the end where the thread for the joint is cut, whereas with flexile joints no leverage power, but only *tensile* strain can be brought to bear. In the latter case very light tubing can be employed with economy in material, cost, labor, and salvage of cotton. Moreover, only by such light flexile apparatus can any considerable number of rows be treated at once from beneath. These facts have been substantiated by tests of stiff and of flexile apparatus this season more fully than they were by the Atlanta tests, in which one light machine undersprayed eighteen rows of cotton, a strip 20 yards wide, at a single drive. The tests this year have been not only of stiff connections, but also of the constructions whereby adjustability of the descending pipes is effected automatically and by hand. These have already been noticed above or in the previous reports in so far as they pertain to the stem or body of the pipe or its distal appendages; hence, next in order may be considered more specifically and in natural sequence the construction and arrangements of the tops of these pipes as planned and tested by me:

I. The stiff hanging tubes have been tried, as already set forth, in firm union with a stiff back-pipe or cross-pipe such as appears in many of the patented sprayers, as Johnson's, Daughtrey's, &c., while sufficient objections to this arrangement for underspraying have already been presented. It is the first construction which naturally suggests itself to any plumber or other mechanic, but presents no special adaptation for the purpose, as has been shown this season and previously.

II. The extremest opposite construction to the foregoing is attained by having radiating flexile tubes from the main to the descending pipes, instead of a straight and stiff cross-pipe. By this arrangement the hanging pipes are swung apart or nearer together independently, and set on a cross-bar or on diverging bars, at spaces to suit rows having different courses or widths.

By way of variation the tubes may radiate only for a part of the distance, and for a space run close beside each other along a supporting bar before reaching the descending parts. The parts upon the support are preferably of metal, and slide readily in peculiarly locked hooks, as simple, easily separable attachments, specially devised for this purpose. Where the descending parts have flexibility to some extent they may drag in the cotton in turning, as stated above. It is shown that they thus do no noteworthy harm to the plants; also that they themselves do not suffer injury. This flexile construction is simple, and generally preferable in combination with the

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flexile connectives between their tops. But should any prefer that the hanging parts be elevated above the plants in turning, this is easily done. For such purpose, and to shorten the leverage in lifting, the descending part should preferably have a flexile joint just below midway, to bend like a knee when the lift is made. The upper half of the descending pipe is rigidly continuous with the stiff parallel part, forming therewith a bent angle, while the proximal end of the parallel part is turned backward as a hollow tubular crank, having its handle-end communicating with one of the radiating or slack hose pipes, which allow the stiff parts to be shifted laterally. By swinging the backward crank-shaped part of the pipe over to a forward position, into a catch, the hanging parts of the pipe are swung upward above the plants and sustained there. This season two, three, and four of these crank-ended pipes were tried, combined with the same bar. When the horizontal part of such a pipe is short or not too heavy it will be shifted laterally automatically by the trailing part by the method already noticed; but where the pipe is too heavy or rough to slide easily the hand of the pumper must occasionally be used upon the proximal or crank end to shove the pipe into such position as will suitably adjust the nozzles to the rows.

In the divergent arrangements thus indicated the shifting or lateral adjustability is permitted by opening or shutting the angles between the diverging tubes, and this is, in its operation, in some sense, analogous to taking out and letting out slack in the connecting parts between the nozzles. By a surplus amount of inflection or slack, by joint or other flexibility, in a tube or tubes connecting the tops of any two neighboring pipes, whether right, left, or mesial, in a system, the two can be separated, approximated, or independently adjusted to the extent desired. By this method the stiff pieces sliding on the bar and supporting the pipe-tops can be short, light, and arranged somewhat end to end, joined in tandem order, with intermediate flexile crooks that may be extended or shortened as operated by the automatic action of the trailing branch. These tandem gangs of light, sliding segments for supporting or supplying the tops of the pipes, have stood a satisfactory test in the cotton this season.

Such parts may also be arranged on bars having a slope backward or downward, as on the A-frames, or other kinds of frames, or they can be set in a somewhat zigzag manner on a cross-bar. This use of a slope gives certain advantages, and characterizes some varieties of apparatus closely related to that just noticed. In these, the pulling of the downward pipe, by its gravitation or friction, causes its top piece, which has an inclination to slide on the slope, to travel in a diagonal direction along on the support and across the rows; but working in opposition thereto is a pull-line or cord having one end on a winder near the hand of the pumper. Letting out the line allows the pipe to travel farther along the slope, and winding it up draws the pipe in the opposite direction. Thus any pipe at a distance can be easily shifted and set at a point to suit by letting out or drawing the line. This principle I have executed in three ways: In the first, the supply tube supports the hung-pipe and slides in eyes situated diagonally with reference to the hung-pipe. In the second, the pipe-top is supplied by a flexile piece of hose, and is supported by a long slide-rod on one or two of its sides, and inserted through loose eyes placed diagonally from the course of traction, as in the foregoing case. In the third instance, the top is similarly supplied by a hose, but is hung by a peculiar locked hook, eye, or loop which glides loosely on a stiffly-set diagonal bar. The simple wooden A-frame answers, and a series of small sloping metal bars of gas-pipe were arranged on a wooden cross-bar. This device worked well. Many kinds of winders would apply, but a simple plan is to wind the small rope or cord around a pair of large eye-screws placed 3 inches apart. The set line can be attached at any point along the sliding parts. Behind the proximal end of the range, through which any pipe-top is to be allowed to slide, the line may pass through a large screw-eye and thence to an extension of the pipe-top above the axis on which it is hung. Then the pipe may be drawn to this place, and by an extra pull its top will be brought down to the eye and the lower parts of the pipe will be tilted upward above the plants for turning, when this feature is desired. * * *

The leading conclusions from the experiments upon the special points in my instructions may be extracted from the above and briefly summarized as follows:

At Selma, I operated the machine taken from the Department and tested the points in question, so far as circumstances permitted. The distinctive feature of the machine, its stiff supporting pipes, unfitted it for the work to be accomplished. As fields could not be found having rows practically of the same regular width as the spaces at which the downward pipes were held stiff by their supporting pipe, that permitted no independent lateral adjustment of the tops of the hanging pipes with reference to each other or to the rows having different or varying widths, this vital impediment at the outset frustrated its use and the obtainment of results dependent thereon. The tests showed that with a pipe-system, without lateral adjustability at the top, very few rows, usually not more than four, can be treated at once. In this small form the whole pipe system can occasionally be moved laterally by hand as the row irregularities require it.

The forks were operated dragging upon the ground, and also set at different

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heights. The ratchet for vertical adjustment subserved this purpose satisfactorily. Where it is desired to spray the base and interior of the plants from beneath, the nozzle arms must necessarily be carried near or on the ground, and with medium to small cotton this method also sprays the top sufficiently well, but if the growth be heavy and dense it proves better to set the forks higher for more thoroughly poisoning the tops.

The stirrer pump worked admirably; but a larger pump of the same kind was necessary to treat a greater number of rows, to ascertain how large a number it is possible or advisable to spray at a time. While the large pump was being constructed and shipped the time limited by my orders expired.

Four rows may be set as the number it is most practical to treat at a time with the kind of machine in question.

The springs of the fork-arms should be larger and have a longer bend than in the samples taken, since the unyielding attachment of the stem-pipes to the stiff supporting pipe above throws on the springs much greater strain than occurs in the machines having descending parts hung to operate independently of each other.

Until my time had expired worms were not abundant enough to study the effects on them of the coarser and finer sprays applied, but the coarser spray was more injurious to the foliage with poisons, and still more so with petroleum.

The standard form of eddy-chamber nozzle was used with discharges of different sizes. The smallest discharge holes, of $\frac{1}{64}$ to $\frac{1}{16}$ of an inch diameter, with very high pressure, gave the most satisfactory results.

The "actual cost, and the actual area covered by a given amount of liquid," vary greatly with the width between the rows, the sizes of the sprays and of the plants, with the number of nozzles, with the amount of pressure applied and the volume capacity of the pump, the velocity at which the machine is drawn, &c. On account of the complexity of the question, and especially because of leakage from imperfect pipe-joints and for want of other and larger apparatus, the question could not be solved with any exactness.

NOTE 57 (p. 326).—The text of this editorial has been given on p. 37, where it is also shown that Mr. Stelle's claim is unwarranted. We have thought it of sufficient historical interest to show upon what the claim was based, and the following passages, copied verbatim from a report made by him while employed by the commission, in accordance with instructions to prepare an account of the past history of the insect, is of interest in this connection. The full report is not published, because it is little more than a compilation from the Department report for 1879—often word for word:

"In June of 1872, the National Agricultural Congress was organized at Saint Louis, Mo., and Prof. C. V. Riley, who was present and took part in the organization, delivered before the body a lecture on economic entomology. Allusion to the cotton worm was made in the course of the lecture. which lead General William H. Jackson, of Nashville, Tenn., and Dr. J. O. Wharton, of Ferry, Miss., to ask for the suggestion of a remedy. In response, Professor Riley gave it as his opinion that Paris green, so effectual as a remedy against the Colorado potato beetle, would, in all probability, prove equally effectual as a remedy against the cotton worm. This, so far as I have been able to learn, (and I have worked the matter up with great care), was the first hint ever thrown to the public in that direction; and there is no risk in asserting that the day in which the hint was thrown out marked the beginning of one of the most important periods in the history of the cotton worm up to the present time: the period of successfully combating it with poisons; in a word, the period of first effectually combating it in any way to an entire saving of the crop.

"Later in the same season, (1st August), the writer of this paper, who had not then heard of Professor Riley's suggestion, recommended, as agricultural editor of the *Mobile Register*, the use of Paris green as a cotton worm destroyer, and Capt. Isaac Donavan, of Mobile County, Alabama, immediately applied it, in obedience to the recommendation, with great success. This is the earliest application of Paris green to the cotton plant that I have been able to trace to date."

"In May of the next year (1873), the National Agricultural Congress assembled at Indianapolis, Ind., where Professor Riley again addressed the meeting, referring at length to Paris green as an insecticide, and unhesitatingly recommending it as a remedy against the cotton worm. His address was widely published through the papers, especially in the South, and thereupon hundreds of planters went at once to applying the poison, meeting with good success in every case where the directions given by Professor Riley were faithfully followed."

With regard to the second paragraph which we have just quoted truth requires us to state that the August (1872) article in the *Mobile Register* (see p. 37) did not appear in the agricultural department of that paper but in the regular editorial

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columns, so that there is nothing to show that it was written by Mr. Stelle beyond his subsequent statement. Moreover, the article in question does not contain a "recommendation" of the use of Paris green, but simply a statement that it was being experimented with at that time. No other similar article was published at that time in the agricultural columns, or in any other part of the *Mobile Register*.

NOTE 58 (p. 350). ANOMIS TEXANA, n. sp.—Average expanse 35mm. Posterior borders of primaries not quite so angulated as in *erosa*, but intermediate between this species and *xylina*. General color of primaries fulvous-gray, ranging from pale fulvous-gray to deep vinous-brown. The ordinary lines are quite well marked, though variable in intensity, and of a darker brown, faintly relieved by pale cinereous. In the commonest specimens there is a dusky patch in the basal region, and the basal line runs in three distinct undulations somewhat obliquely across the basal third of wing. The median line runs from about the middle, or a little outside the middle, of the inner border, either almost straight or outwardly obliquing, and then with a sudden inward notch till it reaches the median vein; it then runs along vein 2 to a little beyond the reniform spot, and thence in a spreading, W-shaped line to costa, which it reaches about the outer third by a more or less decided inward curve. The posterior line begins at the anal angle and runs to vein 2, so as to make a more or less distinct continuation of the median line, and then forks in an irregular, undulating manner to the costa, running parallel with the posterior border. The orbicular consists of an extremely minute white speck upon a slightly deeper shade; the reniform is large and well defined, and either much darker than the brown color or pure white with a faint line of a darker color near the inner border. Head and thorax partake of the general color of primaries, as also palpi and antennæ above. Secondaries and abdomen above rather dull ashy-brown. Under surfaces of primaries dull grayish, slightly nacreous, with the borders pale buff. Along the costa this pale region is suffused with lilaceous, and along the posterior border it is limited by the transverse posterior line, and has a dark brown shade running from the apex to the angle in the middle of posterior border. The median line, in its costal portion, is generally marked by a somewhat S-shaped dark line, well relieved posteriorly by the buff color.

Under surfaces of secondaries pulverulent-lilaceous, with pale buff shade on the inner third, and with a discal spot and two well-marked transverse, slightly undulate, lines on the outer third and parallel with the posterior border. Described from 5 ♂'s, 6 ♀'s.

Of course it is impossible to decide, from Hübner's description, just what *Anomis exacta* is, but a careful study of his figures shows it to be a smaller species and much more ferruginous, with a paler reniform, and the lines somewhat differently arranged; also with the primaries less angular.

NOTE 59 (p. 353). DRASTERIA ERECHTEA. *Egg*.—Nearly globular in form, slightly flattened at point of attachment. Apex with roundish facets; sides rather coarsely longitudinally ribbed. The alternate ribs rather shorter than the others, as in the egg of Aletia. General color grayish-green, with irregular grayish-brown markings; the facetted apex always grayish-brown.

Pupa.—About 18mm (three-fourths of an inch) in length. Head, thorax and appendages dark brown, abdomen light brown; the incisures between the joints deep, and of a yellowish-brown color. Whole surface of the body somewhat pruinose. Tip of the body bluntly rounded and furnished with eight slender and moderately long hooklets.

NOTE 60 (p. 358).—This description is as follows:

"The insect I will call *Phalaena zea* (corn-moth) until it is more correctly classified. It is of a pale yellow or shining ash color—length of body and wings one and one-eighth of an inch, the wings expand two inches horizontal, the upper wings covering the lower; below the center and near the border of the upper wings, are two dark spots; there are some two or three indistinct ones on each upper wing, end of the

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wing whitish, a wavy dark band near the border. Thorax slightly convex, downy; abdomen color of wings, downy; proboscis folded spirally underneath, double, half inch long; eyes large, clear, yellowish-green. Legs six, antennæ fusiform, palpi very hairy, flies only late in the evening and at night, lies concealed in the day in jams of the fence, around stumps and in the grass and weeds, flies rapid and low."

NOTE 61 (p. 358).—*Heliothis umbrosus.* Grote's description is as follows:

"Anterior wings yellowish-gray crossed by several indistinct irregular darker shaded lines. Discal spot blackish beyond which is a row of minute black dots one on each nervule running parallel with the outer margin of the wing and connected with each other by a faint waved line the curvatures turned inward toward the base of the wing; fringes dark. Posterior wings yellowish-white without markings except a broad blackish band running parallel with the outer margin and which is partly interrupted near the centre by a space of a similar color to the rest of the wing; fringes white. Under surface of the wings pale showing the black discal spot on the anterior wings plainly, outside of which is a blackish transverse band and a small blackish streak near the upper margin. Under surface of posterior wings immaculate except a faint blackish shade near the outer margin. Head, thorax and tegulae yellowish-gray, darker than the anterior wings. Body grayish, clothed at the sides with whitish hairs, and darkening towards the tip. Exp. 1¼ inches."—[Proc. Ent. Soc. Phila., vol. 1 (1861–1863), p. 219.

NOTE 62 (p. [64]).—We reproduce almost *verbatim* the remarks on Mr. Edes' material, as given in the *American Entomologist*, vol. iii, pp. 128–129:

[Mr. Edes kindly accompanied his communication with specimens, upon which we will add a few remarks. The worm that takes the place of our Aletia is, both by the colored drawing and the specimens sent, easily distinguished from Aletia. The four moths are in poor condition and show some variation. The species is one of the smallest of the genus *Anomis*, and between *illita* Gn. and Hübner's figure of *exacta*, of which Professor Grote kindly had a copy made for us. In the larva the front pair of abdominal prolegs is perfectly obsolete and the second pair of nearly the same size as the others. The piliferous spots are reddish without pale annulation. The chrysalis has the cremaster less swollen at tip, but otherwise, except in smaller size, is undistinguishable.

The egg is so similar to that of Aletia that it is doubtful whether there are any constant distinguishing characters; the ribs in the single specimen examined are somewhat fewer in number and consequently more marked.

That this is the "Cotton Worm" of Bahia is interesting from the fact that Aletia was described by Hübner from that place. If, as we cannot well doubt, Mr. Grote has correctly determined Hübner's figure of Aletia to represent Say's *Noctua xylina*, it will also yet be found there. There is a possibility, however, that the figure has misled, and the description of Hübner is certainly of no value as a guide.

The cotton bolls contained the following insects, which all appear to have fed upon the seeds: (1) a small Tineid, badly rubbed but distinct from the species so abundantly found in the United States under similar conditions, and which is figured by Professor Glover as possibly *T. granella*, but is, as Mr. Chambers informs us, a new species of *Laverna*. It is, however, a different species. (2) Several specimens of *Hypothenemus eruditus* Westw. (*hispidulus* Lec.), which has also been found in diseased cotton bolls in the United States and on the Bahama Islands, and which also bores in the twigs of the dead plants. (3) Two specimens of a *Paratenetus*, differing from the allied North American *P. punctatus*, which is found is diseased cotton bolls in the United States, by its very strongly dentate thorax. (4) One specimen of a Cryptophagid beetle, apparently undescribed and not occurring in the United States. (5) Four specimens of *Arœocerus fasciculatus*, a cosmopolitan beetle found in articles of commerce and frequently observed in diseased cotton bolls in the Southern States.

The large bug is the Cotton Stainer (*Dysdercus suturellus* H.-S.), also found in the United States and greatly injurious to cotton on the Bahamas.]

NOTE 63 (p. [65]).—A large Sphingid larva, probably of *Macrosila rustica*.

NOTE 64 (p. [66]).—The worms sent by Señor Enriquez were the genuine Aletia, as shown on p. 41.

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